

WORKING GROUP ON MACKEREL AND HORSE MACKEREL EGG SURVEYS (WGMEGS)

VOLUME 3 | ISSUE 82

ICES SCIENTIFIC REPORTS

RAPPORTS
SCIENTIFIQUES DU CIEM



International Council for the Exploration of the Sea Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

ISSN number: 2618-1371

This document has been produced under the auspices of an ICES Expert Group or Committee. The contents therein do not necessarily represent the view of the Council.

© 2021 International Council for the Exploration of the Sea.

This work is licensed under the [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/) (CC BY 4.0). For citation of datasets or conditions for use of data to be included in other databases, please refer to [ICES data policy](#).



ICES Scientific Reports

Volume 3 | Issue 82

WORKING GROUP ON MACKEREL AND HORSE MACKEREL EGG SURVEYS (WGMEGS)

Recommended format for purpose of citation:

ICES. 2021. Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS).
ICES Scientific Reports. 3:82. 40pp. <https://doi.org/10.17895/ices.pub.8249>

Editors

Gersom Costas • Brendan O'Hea

Authors

Paula Alvarez • Maria Manuel Angelico • Finlay Burns • Gersom Costas • Thassya dos Santos Schmidt
Bastian Huwer • Dolores Garabana • Matthias Kloppmann • Maria Korta • Richard Nash
Cristina Nunes • Ismael Nuñez-Riboni • Brendan O'Hea • Isabel Riveiro • Paz Sampedro
Antonio Solla • Anders Thorsen • Jens Ulleweit • Cindy van Damme



ICES
CIEM

International Council for
the Exploration of the Sea
Conseil International pour
l'Exploration de la Mer

Contents

| | | |
|----------|---|-----|
| i | Executive summary | ii |
| ii | Expert group information..... | iii |
| 1 | Plan and coordinate the Mackerel/Horse Mackerel Egg Surveys in the ICES areas 4 to 9. (ToR a) | 1 |
| 1.1 | Planning of the 2022 mackerel and horse mackerel egg survey in the western and southern areas (ToR a)..... | 1 |
| 1.1.1 | Countries and Ships Participating | 1 |
| 1.1.2 | Survey Design..... | 1 |
| | Period 2 | 2 |
| | Period 3 | 2 |
| | Period 4 | 2 |
| | Period 5 | 3 |
| | Period 6 | 3 |
| | Period 7 | 3 |
| 1.1.3 | Sampling Areas and Sampling Effort..... | 13 |
| 1.1.4 | DEPM survey for southern horse mackerel | 15 |
| 1.2 | Planning of the 2021 mackerel egg survey in the North Sea | 17 |
| 2 | Plan and Coordinate the sampling and laboratory analysis for mackerel/horse mackerel fecundity and atresia (ToR b) | 18 |
| 2.1 | Planning and sampling programme for the mackerel and horse mackerel AEPM and DEPM adult parameters..... | 18 |
| 2.1.1 | Sampling for mackerel fecundity and atresia in the Western and Southern areas | 18 |
| 2.1.2 | Western horse mackerel DEPM adult parameter sampling | 18 |
| 2.1.3 | Southern horse mackerel DEPM adult parameter sampling | 18 |
| 2.1.4 | DEPM sampling for mackerel..... | 19 |
| 3 | Review and update the manuals for the Mackerel and Horse Mackerel Egg Surveys and fecundity estimation (Tor c,d) | 20 |
| 3.1 | Review procedures for egg sample sorting, species ID, staging, data submission and subsampling (ToR c, e) including update of manual | 20 |
| 3.1.1 | Survey boundaries rule | 20 |
| 3.2 | Review and update the manuals for the Mackerel and Horse Mackerel Egg Surveys and fecundity estimation..... | 21 |
| 4 | MEGS biological and fecundity database | 22 |
| 5 | Shift from North Sea mackerel egg survey to the same year as the Atlantic survey | 24 |
| 6 | Evaluation of sampling strategies..... | 25 |
| 7 | Western horse mackerel egg surveys..... | 26 |
| 8 | Exploratory egg survey in 2021 | 29 |
| 9 | References | 31 |
| Annex 1: | List of participants..... | 32 |
| Annex 2: | Resolutions | 33 |
| Annex 3: | Abstracts of presentations given during the WGMEGS meeting..... | 36 |

i Executive summary

The ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS) coordinates the mackerel and horse mackerel egg survey in the Northeast Atlantic and the mackerel egg survey in the North Sea. In April 2021, WGMEGS met to plan the 2021 North Sea mackerel egg survey and the 2022 Mackerel and Horse Mackerel Egg Survey.

Netherlands and Denmark will participate in the 2021 North Sea survey which will use the daily egg production method (DEPM) rather than annual egg production method (AEPM).

Germany, Ireland, Netherlands, Scotland, Portugal, Spain, Faroe Islands and Norway will participate in the 2022 MEGS survey. This survey will be based on six regular sampling periods (Section 1) and will commence with the Portuguese DEPM survey for southern horse mackerel. The survey plan will be further elaborated during the course of 2021 and an updated survey plan will be presented after the Workshop on Mackerel, Horse Mackerel and Hake Egg Identification and Staging (WKMACHIS) and the Workshop on Adult Egg Production Methods Parameters estimation in mackerel and horse mackerel (WKAEPM) are held in late 2021. These workshops are essential to maintain the quality assurance of the mackerel and horse mackerel egg surveys and it is strongly advised that participating analysts attend these workshops.

In 2022, the MEGS survey will continue as an AEPM survey; however, as with the surveys in 2013, 2016 and 2019, the intention will be to also carry out intensive DEPM sampling during expected peak spawning periods of both species, in an attempt to calculate a DEPM spawning stock biomass (SSB) estimate. The periods highlighted as being the likely peak spawning periods are periods 3 and 4 for mackerel, period 6 and 7 for western horse mackerel and period 2 for southern horse mackerel. Fecundity analysis will be conducted by Norway (IMR), the Netherlands (WMR), Scotland (MSS), Ireland (MI), Portugal and Spain (IEO and AZTI).

The 2019 survey found the peak spawning for western horse mackerel in July but egg production was much lower than recent surveys had reported. Concern has been expressed as to whether the MEGS surveys are capturing the horse mackerel spawning sufficiently. WGMEGS has been considering if horse mackerel spawning had shifted to even later in the year or if the reduction in egg numbers has been in response to the poor status of the stock resulting in a patchier distribution of eggs.

WGMEGS considered a proposal to move the timing of the North Sea survey to the same year as the western surveys. If approved this survey would now be conducted by Denmark and England in 2022. Their participation would not lead to any reduction of available effort for the western surveys in 2022. This proposed timing change may be subject to a review at the EU Regional Coordination meeting before it can be implemented.

ii Expert group information

| | |
|-----------------------------------|---|
| Expert group name | Working Group On mackerel and horse mackerel egg surveys (WGMEGS) |
| Expert group cycle | Multiannual fixed term |
| Year cycle started | 2021 |
| Reporting year in cycle | 1/3 |
| Chair(s) | Brendan O'Hea, Ireland |
| | Gersom Costas, Spain |
| Meeting venue(s) and dates | 26–29 April 2021, virtual meeting, (29 participants) |

1 Plan and coordinate the Mackerel/Horse Mackerel Egg Surveys in the ICES areas 4 to 9. (ToR a)

1.1 Planning of the 2022 mackerel and horse mackerel egg survey in the western and southern areas (ToR a)

1.1.1 Countries and Ships Participating

Germany, Ireland, Netherlands, Scotland, Portugal, Spain (IEO), Spain (AZTI), Faroe Islands and Norway will participate in the mackerel and horse mackerel egg surveys in the western and southern area in 2022. Provisional dates, (and vessels where possible), for the forthcoming surveys can be found in Table 1.1. Results from the last two surveys provided a strong signal of further significant challenges facing the survey, with both a spatial as well as a temporal shift in mackerel peak spawning. In 2016 a move away from February/March to May, and from the Bay of Biscay to a large area to the west of Scotland was reported. This resulted in an inability to fully delineate the spawning boundaries in the North and West. In 2019 peak spawning was found to have taken place in April with the largest spawning densities being recorded along the shelf edge west of Orkney and Shetland. As a result, surveying in February in the western area has been discontinued, with effort instead being reallocated to March. The proposed survey plan for 2022 has been devised to attempt to manage the available effort such that it is able to adequately survey the Northern areas whilst at the same time retaining sufficient survey effort to successfully capture the start of the spawning season. Survey coverage of the western and southern areas is given by area and Period in Table 1.1. Detailed maps of survey coverage by Period are given in Figures 1.1 – 1.6. Both vessel availability and area assignments are provisional and will be finalised by the survey coordinator at WKMAHIS, the workshop on mackerel, horse mackerel and hake eggs identification and staging, in October 2021.

The survey coordinator for the 2022 survey will be Brendan O' Hea, Marine Institute, Galway, Ireland.

1.1.2 Survey Design

The AEPM survey design for mackerel and horse mackerel for 2022 will not change, however another attempt will be made to estimate DEPM adult parameters for both species. This will require additional sampling during the perceived peak spawning periods for both species, as identified from the 2010 surveys during WKMSPA (ICES, 2012). Based on recent survey results during the 2022 survey this sampling will take place during Periods 3 and 4 for mackerel, and Periods 6 and 7 for horse mackerel.

In 2022 the survey will be split into six sampling Periods, and the design and operational survey plan will be very similar to that deployed during 2019. Once again Faroes and Norway will participate in the survey during May and June, which will expand the geographic range of the survey in the North during those Periods. In 2022 Norway will participate in May while Faroes will conduct their survey in early June.

Period 2 (mid January to mid February) will involve a survey in ICES division 27.9.a only. In 2022 the survey effort in division 27.9.a will be targeted on a single extended DEPM survey, (see section 1.1.4). No sampling in division 27.9.a will take place after the end of Period 2. During Period 1-2 ovary sampling is planned from commercial vessels to collect pre-spawning fish samples in the southern and western area

Sampling in the western area will commence in second half of February (Period2). Scotland will carry out limited sampling on their IBTS survey off the west coast of Scotland. During Period 3 the survey will concentrate on the Cantabrian Sea, Bay of Biscay, the Celtic Sea, West of Ireland and West of Scotland.

Period 4 will see sampling continue from the Cantabrian Sea to the northwest of Scotland, while in Period 5 this sampling will extend into Faroese and Norwegian waters. No sampling will take place in the Cantabrian Sea, or the southern Bay of Biscay, after Period 5. Period 6 will see the survey area continue to delineate a northern boundary in Faroese and Norwegian waters. In Period 7 the survey is designed to identify a southern boundary of spawning and to survey all areas north of this. The deployment of vessels to areas and Periods is summarised in Table 1.2.

In 2013 the peak of mackerel spawning occurred in February, in the Bay of Biscay, however in 2016 and 2019 it occurred later in the year, in more northern waters. Due to the expansion of the spawning area that has taken place since 2010 the emphasis in 2022 will once again be focussed on maximising area coverage. Cruise leaders will be asked to cover their **entire** assigned area using alternate transects and then use any remaining time to fill in the missed transects. If time is short this should be concentrated in those areas identified as having the highest densities of egg abundance. Particular points to note are:

Period 2

Only coast of Portugal, division 27.9.a, in the southern area, will be surveyed in Period 2. This will be the Portuguese DEPM survey (Figure 1.1).

Prior to the start of the Period 3 surveys Scotland will be undertaking their IBTS survey off the west coast of Scotland. During this survey, some sampling effort has been allocated to MEGS sampling, (Figure 1.1). Due to the low numbers of samples expected to be collected, and potentially low numbers of eggs in these samples, this data could have major skewing effect if it was included in Period 3. As a result, it has been allocated to Period 2, and will be dealt with as a stand-alone survey during the MEGS data analysis next year.

Period 3

Period 3 marks the commencement of the western area surveys. As a direct consequence of what was reported during the 2016 and 2019 surveys the timing of this Period has reverted to what would have been considered a more traditional calendar Period. Consequently, in 2022 the Period 3 Irish survey will commence in March instead of February which was the date of deployment during the previous 2 surveys.

Period 3 surveys will be carried out by Spain (IEO), Spain (AZTI), Germany, and Ireland. IEO will survey in the Cantabrian Sea and the southern Bay of Biscay. AZTI will survey the northern part of the Bay of Biscay. Germany will cover the Celtic Sea and west of Ireland. Ireland will survey the area west of Scotland, as well as northwest Ireland, (Figure 1.2).

WGMEGS have undertaken to collect additional adult DEPM samples in Periods 3 and 4 for mackerel. It is also especially desirable that as far as is possible comprehensive survey coverage is achieved within this enhanced area and this should be the prime consideration when completing the second sweep of the survey area during this Period.

Period 4

Period 4 surveys will be carried out by Spain (IEO), Germany, and Scotland. IEO will survey in the Cantabrian Sea and the southern Bay of Biscay. Germany will conduct their survey in the northern part of the Bay of Biscay, as well as the Celtic Sea and west of Ireland. Scotland will survey the area west of Scotland, as well as northwest Ireland, (Figure 1.3).

WGMEGS will continue to collect additional adult DEPM samples for mackerel in this Period.

Period 5

During Period 5 sampling will be carried out by four vessels and interesting to note that this Period is when the survey is operating at its greatest spatial extent with a latitudinal range spanning from the Cantabrian Sea in the south to the Faroe Islands in the North. AZTI will conduct a targeted DEPM survey for anchovy in the Cantabrian Sea and the southern Bay of Biscay. The design of this survey is therefore constrained by that purpose. The survey does however provide data on mackerel and horse mackerel egg numbers. Netherlands will sample in the north of the Bay of Biscay, the Celtic Sea and west of Ireland. Scotland will sample to the west of Scotland and northwest of Ireland, and Norway will survey the waters north of 60°N, between Iceland and the Norwegian coast (Figure 1.4).

Period 6

In Period 6 three vessels will survey the area between the Bay of Biscay and the Northern area.

Netherlands will survey in the Bay of Biscay, the Celtic Sea and southwest of Ireland. Ireland will survey northwest of Ireland and west of Scotland. Faroes will carry out a survey north of 59° 30'N, in Faroese waters and towards the Norwegian coast. As in Period 5 this will expand the survey range and attempt to secure a northern boundary within this Period, (Figure 1.5). The Dutch vessel will commence the survey along the southern boundary of the designated area although its exact latitude will depend on the results from Period 5. Providing adequate survey coverage during this Period will once again be challenging.

In 2022, as with the mackerel in Periods 3 and 4, WGMEGS have undertaken to collect additional adult horse mackerel DEPM samples during Periods 6 and 7. As with Periods 4 and 5 however every effort should be made to achieve as comprehensive coverage as is possible within this enhanced area.

Period 7

In Period 7 only one vessel will be available and will have to cover the entire spawning area. This assignment will be undertaken by Scotland. As with Period 6 the southern boundary, (starting location), will be dictated by the results of the previous Period. Irrespective of this an alternate transect design will be necessary, (Figure 1.6).

For the last three surveys this final survey Period has provided the peak of spawning for horse mackerel, although the numbers of eggs being found is decreasing. As a result, Scotland have been asked to survey every transect in areas where historically, high densities of horse mackerel eggs have been observed.

Horse mackerel DEPM sampling will continue during this Period.

Table 1.1. Countries, vessels, areas assigned, dates and sampling Periods for the 2022 surveys

| Country | Vessel | Areas | Dates | Period |
|---------------|-------------------|--|--|--------|
| Portugal | Vizconde de Eza | Cadiz, Portugal & Galicia | 22 nd Jan – 22 nd Feb | 2 |
| Spain (IEO) | Vizconde de Eza | Cantabrian Sea & Bay of Biscay | 7 th Mar – 30 th Mar | 3 |
| | | Biscay & Cantabrian Sea | 11 th Apr – 4 th May | 4 |
| Germany | Walter Herwig III | West Ireland & Celtic Sea | 21 st Mar – 25 th Apr | 3 , 4 |
| Netherlands | Tridens | Bay of Biscay & Celtic Sea | 9 th May – 27 th May | 5 |
| | | Bay of Biscay & Celtic Sea | 6 th June – 24 th June | 6 |
| Spain (AZTI) | Ramon | Bay of Biscay | 19 th Mar – 9 th Apr | 3 |
| | Margalef | Bay of Biscay & Cantabrian Sea | 2 nd May – 29 th May | 5 |
| Ireland | Celtic Explorer | Celtic Sea & Bay of Biscay | 3 rd Mar – 23 rd Mar | 3 |
| | Charter | West of Ireland & west of Scotland | 6 th June – 26 th June | 6 |
| Scotland | Scotia | West of Ireland & west of Scotland | IBTS (2 nd half of Feb) | 2 |
| | Charter | West of Ireland & west of Scotland | 14 th Apr – 27 th Apr | 4 |
| | Scotia | West of Ireland & west of Scotland | 8 th May – 28 th May | 5 |
| | Charter | Celtic sea, West of Ireland & West of Scotland | 4 th July – 24 th July | 7 |
| Faroe Islands | Jakup Sverri | Faroes & Shetland | 1 st June – 15 th June | 6 |
| Norway | Charter | Faroes, west of Norway | 8 th May – 28 th May | 5 |

Table 1.2. Periods and area assignments for vessels by week for the 2022 survey. Area assignments and dates are provisional.

| Week | Starts | Area 9a | Cantabrian Sea | Biscay | Celtic sea | West of Ireland | West of Scotland | Northern area | Period |
|------|------------|---------|-------------------|--------------------|------------|-----------------|------------------|---------------|--------|
| 3 | 09-Jan-22 | | | | | | | | 1 |
| 4 | 16-Jan-22 | PO1 | | | | | | | 2 |
| 5 | 23-Jan-22 | PO1 | | | | | | | 2 |
| 6 | 30-Jan-22 | PO1 | | | | | | | 2 |
| 7 | 06-Feb-22 | PO1 | | | | | | | 2 |
| 8 | 13-Feb-22 | PO1 | | | | | | | 2 |
| 9 | 20-Feb -22 | PO1 | | | | SCO (IBTS) | SCO (IBTS) | | 2 |
| 10 | 27-Feb-22 | | | | | SCO (IBTS) | SCO (IBTS) | | 2 |
| 11 | 06-Mar-22 | | | IEO1 | IRL 1 | IRL 1 | IRL 1 | | 3 |
| 12 | 13-Mar-22 | | | IEO1 | IRL 1 | IRL 1 | IRL 1 | | 3 |
| 13 | 20-Mar-22 | | IEO1 | AZTI1 | GER1 | IRL 1 | IRL 1 | | 3 |
| 14 | 27-Mar -22 | | IEO1 | AZTI1 | GER1 | GER1 | | | 3 |
| 15 | 03-Apr-22 | | | AZTI1 | GER1 | GER1 | | | 3 |
| 16 | 10-Apr-22 | | IEO2 | IEO2 | GER2 | GER 2 /SCO1 | SCO1 | | 4 |
| 17 | 17-Apr-22 | | IEO2 | IEO2 | GER2 | GER 2 /SCO1 | SCO1 | | 4 |
| 18 | 24-Apr -22 | | IEO2 | IEO2 | GER2 | GER 2 /SCO1 | SCO1 | | 4 |
| 19 | 1-May-22 | | IEO2/AZTI2 (DEPM) | IEO2 | | | | | 4 |
| 20 | 8-May-22 | | AZTI2 (DEPM) | AZTI2 (DEPM)/ NED1 | NED1 | NED1 / SCO2 | SCO2 | NOR | 5 |
| 21 | 15-May-22 | | | AZTI2 (DEPM)/ NED1 | NED1 | NED1 / SCO2 | SCO2 | NOR | 5 |
| 22 | 22-May -22 | | | AZTI2 (DEPM)/ NED1 | NED1 | NED1 / SCO2 | SCO2 | NOR | 5 |
| 23 | 29-May-22 | | | | | | | FAR | 6 |
| 24 | 5-Jun-22 | | | NED2 | NED2 | IRL2 | IRL2 | FAR | 6 |
| 25 | 12-Jun-22 | | | NED2 | NED2 | IRL2 | IRL2 | FAR | 6 |

| | | | | | | | | | |
|----|------------|--|--|------|------|------|------|--|---|
| 26 | 19-Jun -22 | | | NED2 | NED2 | IRL2 | IRL2 | | 6 |
| 27 | 26-Jun -22 | | | | | | | | 6 |
| 28 | 3-Jul-22 | | | | SCO3 | SCO3 | SCO3 | | 7 |
| 29 | 10 –Jul-22 | | | | SCO3 | SCO3 | SCO3 | | 7 |
| 30 | 17-Jul-22 | | | | SCO3 | SCO3 | SCO3 | | 7 |
| 31 | 24-Jul-22 | | | | SCO3 | SCO3 | SCO3 | | 6 |

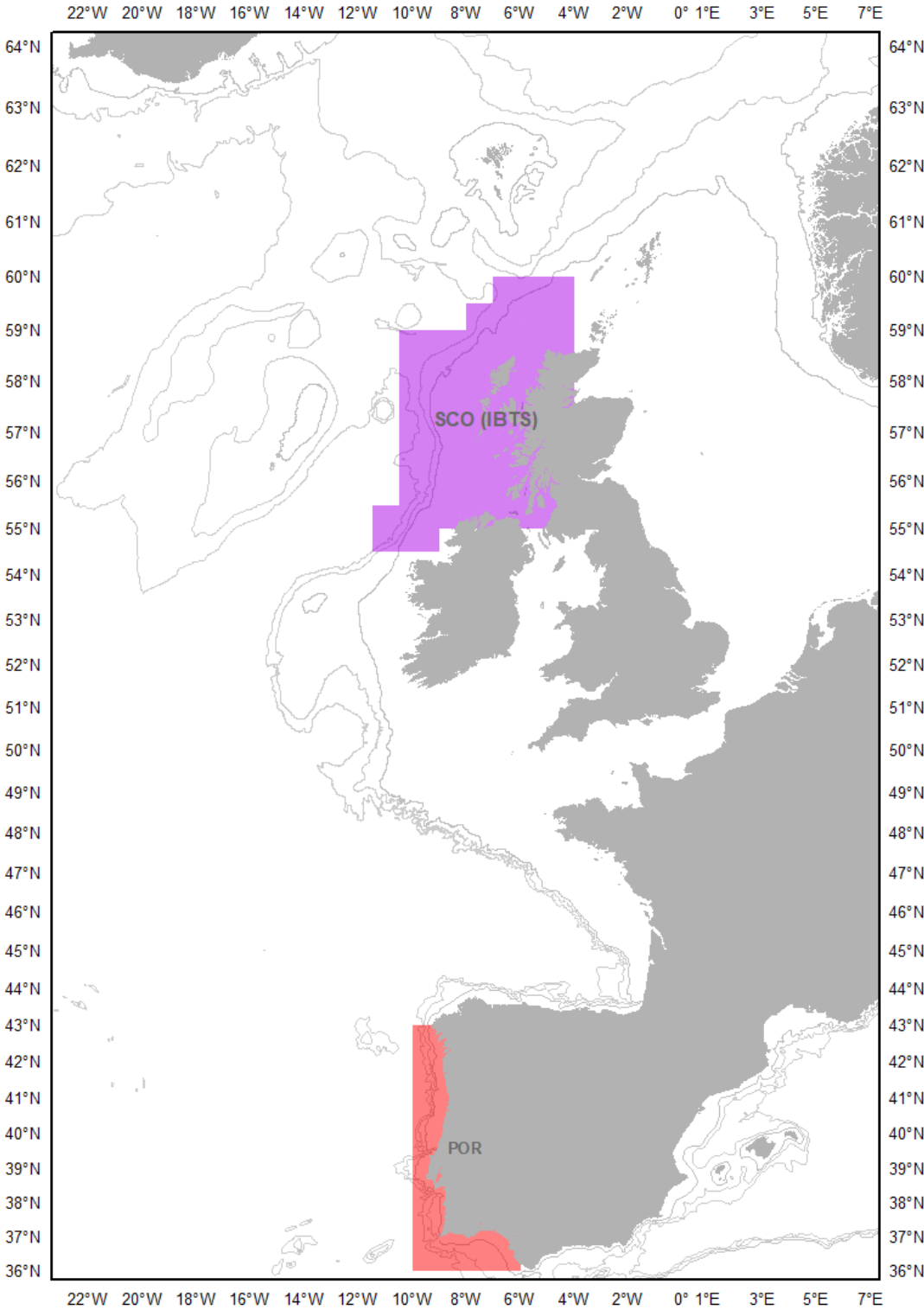


Figure 1.1. Survey plan for Period 2

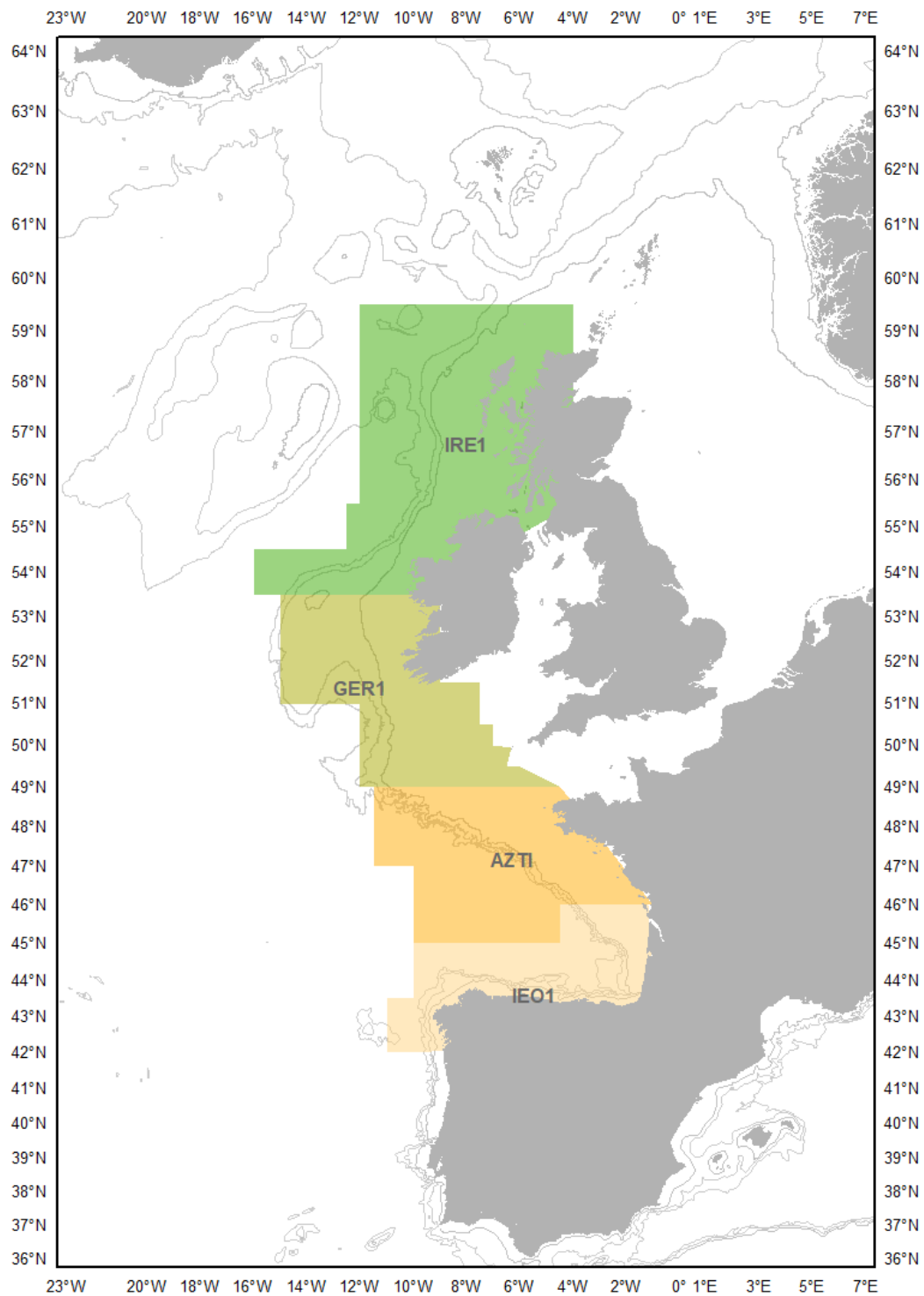


Figure 1.2. Survey plan for Period 3

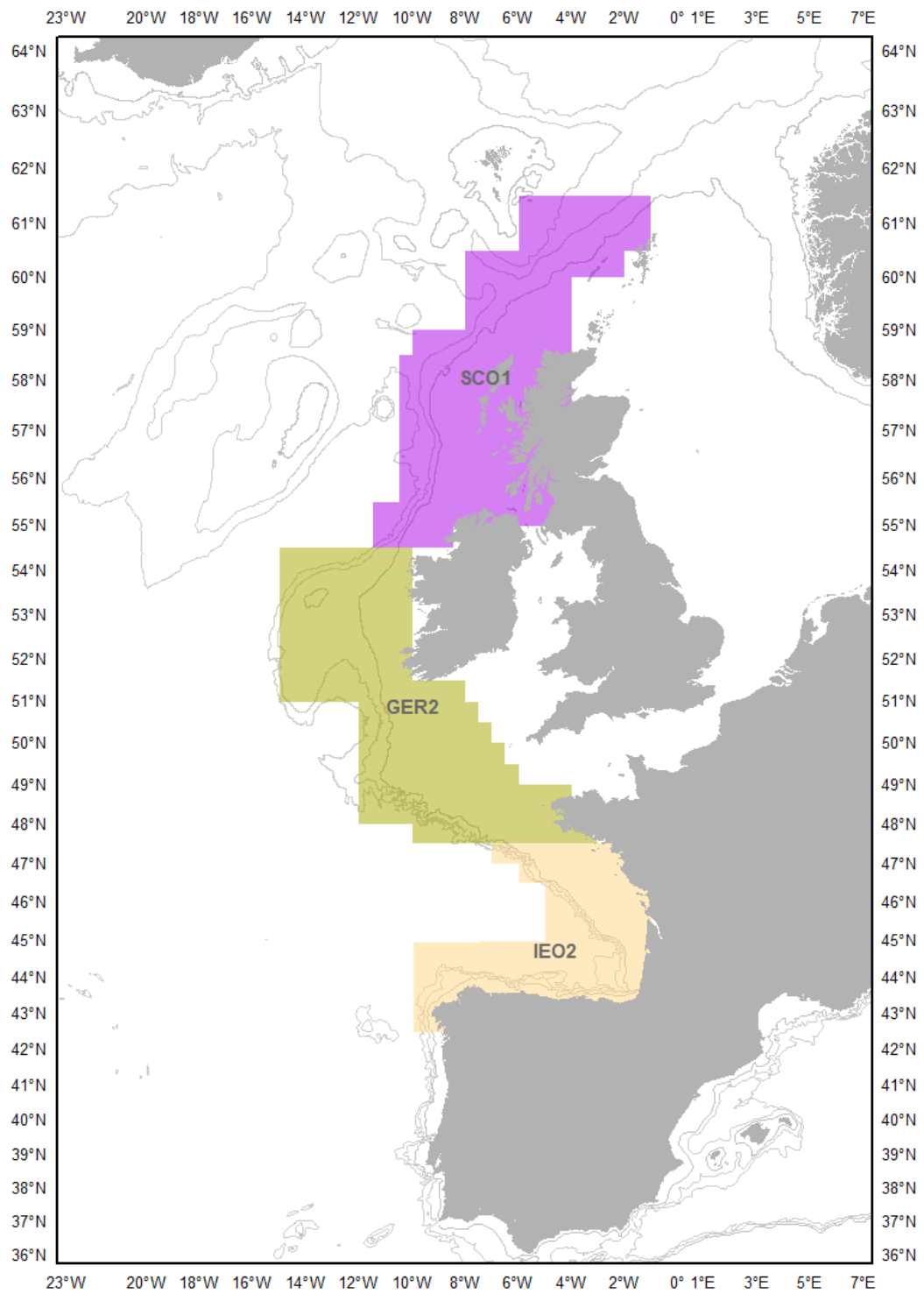


Figure 1.3. Survey plan for Period 4

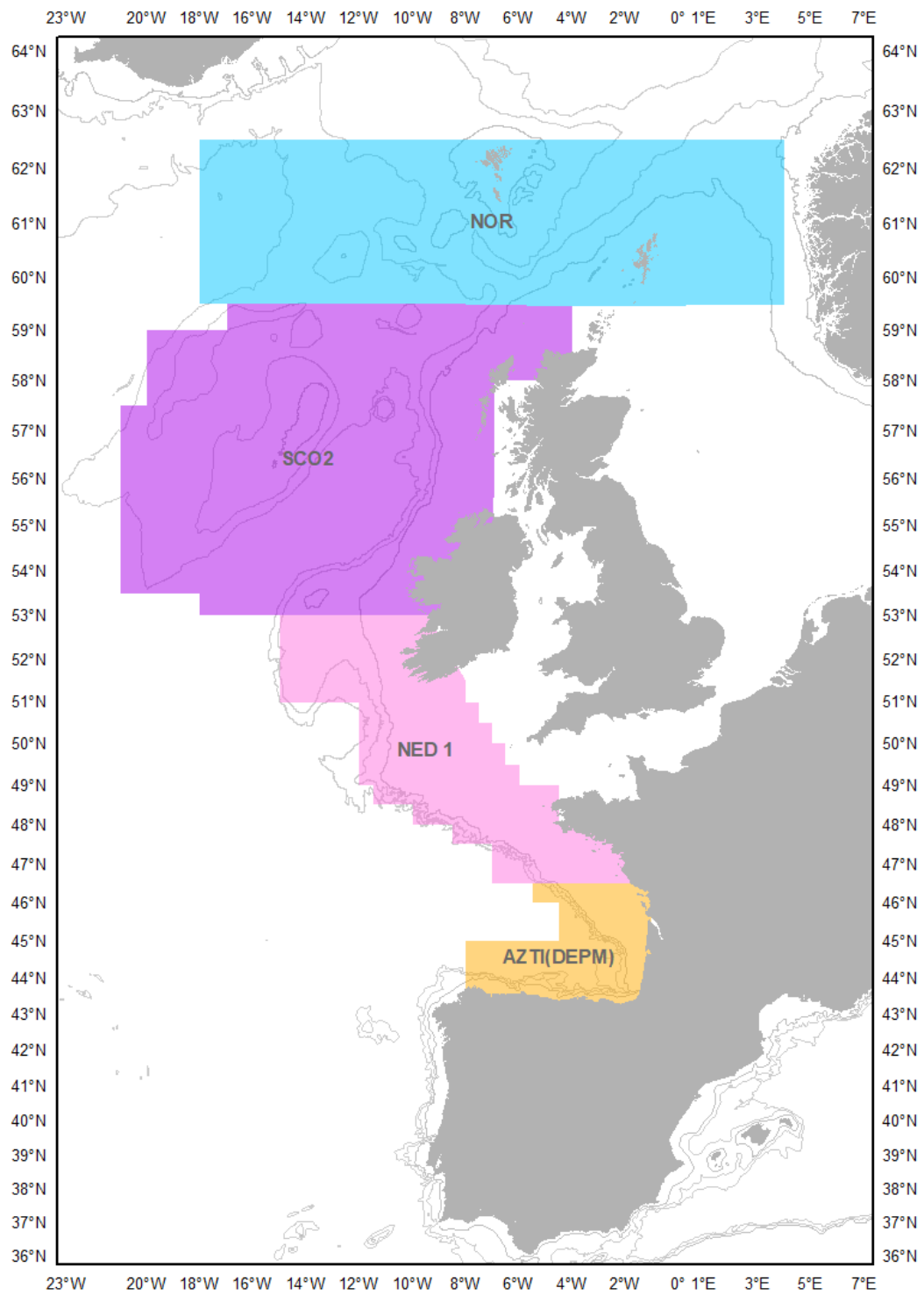


Figure 1.4. Survey plan for Period 5

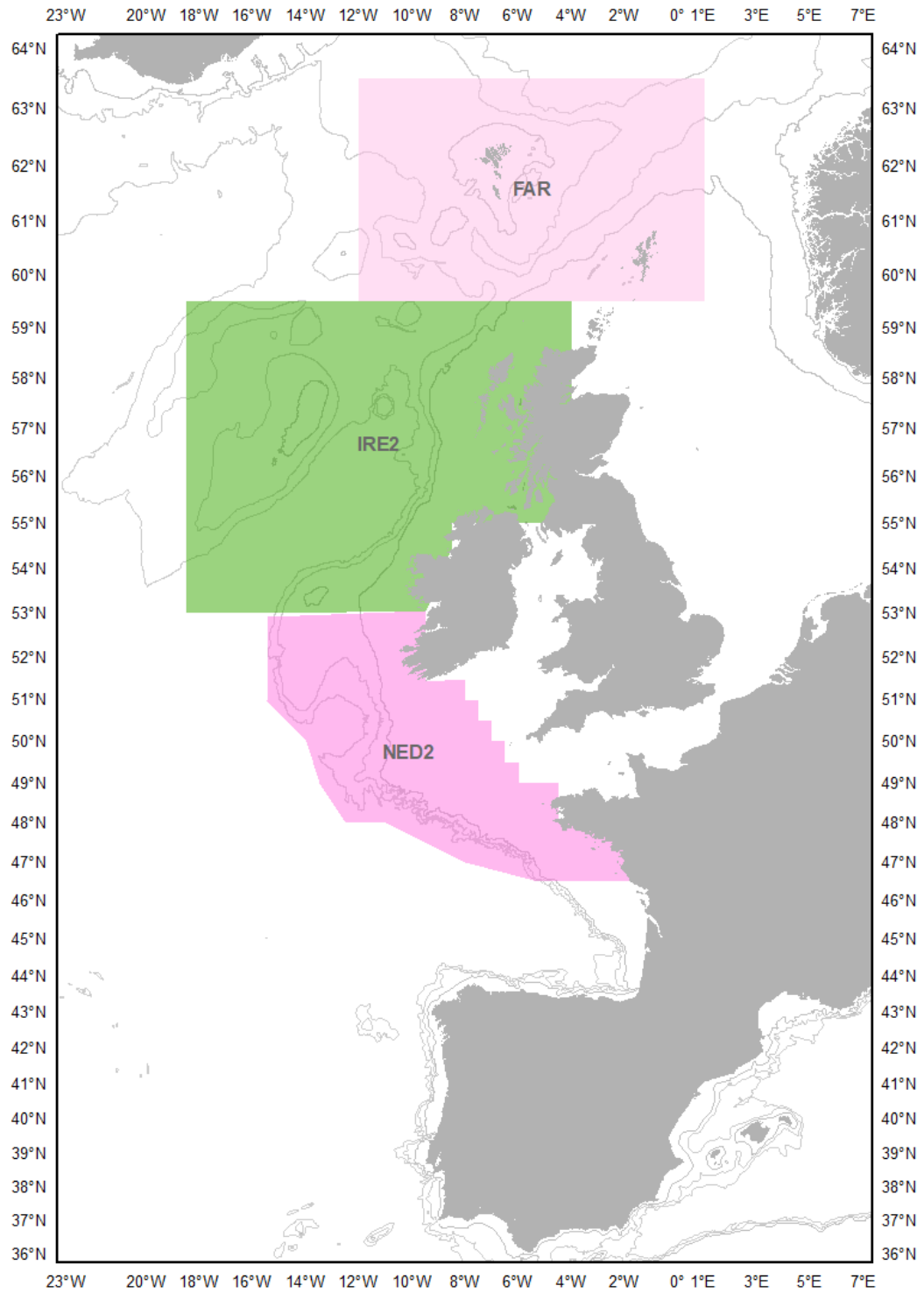


Figure 1.5. Survey plan for Period 6

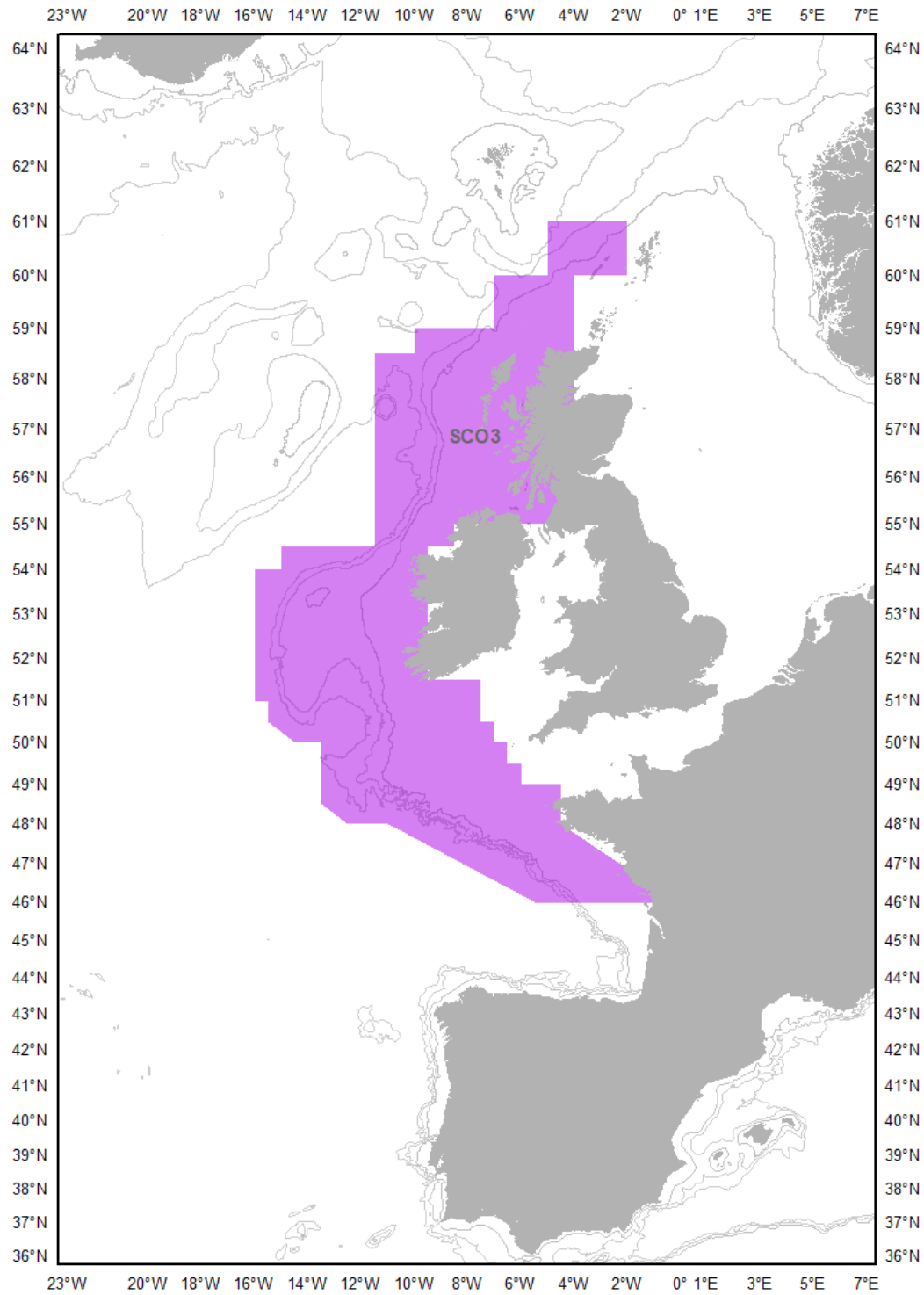


Figure 1.6. Survey plan for Period 7

1.1.3 Sampling Areas and Sampling Effort

As in 2019 it was decided that the spatial and temporal distribution of sampling in 2022 would be designed to ensure maximum coverage of both mackerel and horse mackerel spawning and that estimates of stage 1 (stage 1a and 1b) annual egg production would be made for both species.

Since the surveys were started in 1977 considerable changes have been made to the standard sampling area and these have been described in Section 8.4 (ICES, 1994). In 1995 changes were made to the western boundaries of the western area because of the unusual westerly distribution of mackerel eggs which occurred during Period 3 in, 1992 (ICES, 1996). Examination of the 1995 egg distributions prior to the 1998 survey resulted in the addition of further rectangles to the standard sampling area. A total of eight rectangles were added at the northern edge and twenty-five on the western edge between latitude 45° 30'N and 51°N (ICES, 1997). Examination of the 1998 survey data showed that the distribution of mackerel and horse mackerel spawning in both the western and southern areas was adequately covered with the exception of mackerel spawning from mid-May to July at the northern edge of the western standard area. As a result, some additional rectangles were added to the standard area north of latitude 58° 30'N.

Based on this steady growth of the “standard area” every survey, the Working Group agreed at the Dublin meeting (ICES, 2002) to reconsider its use. It was agreed that the existing “standard area” should be retained **only as a guide** to the core survey area for cruise leaders, and that the extent of coverage should be decided based on finding the edges of the egg distribution only, i.e. boundaries should be set based on the adaptive sampling guidelines, getting two consecutive zero samples. The core areas for the western and southern surveys for both species are presented in Figures 1.7 and 1.8. A more detailed survey map of the Iberian areas as surveyed by IPMA can be found in Figure 1.9. Section 2.1.3 also provides a description of the Portuguese DEPM survey.

The sampling area in the Portuguese coast in the southern area has been modified from the design used in 2001 and previously. The stations have been placed closer together in the onshore/offshore direction and further apart in the alongshore direction.

As stated above the survey protocols noted that the limits of the survey in both the western and southern areas should be established on the basis of two consecutive zero samples, and not by the boundaries on a map. In recent surveys, due to the expansion of the area needing to be surveyed, it is sometimes very difficult to get two zero samples in certain survey Periods. As a result, current guidelines have been changed to require a number of low counts, with the final decision on turning off a transect left to the experience of the scientist in charge of each survey. WKMACHIS should advise what this number should be.

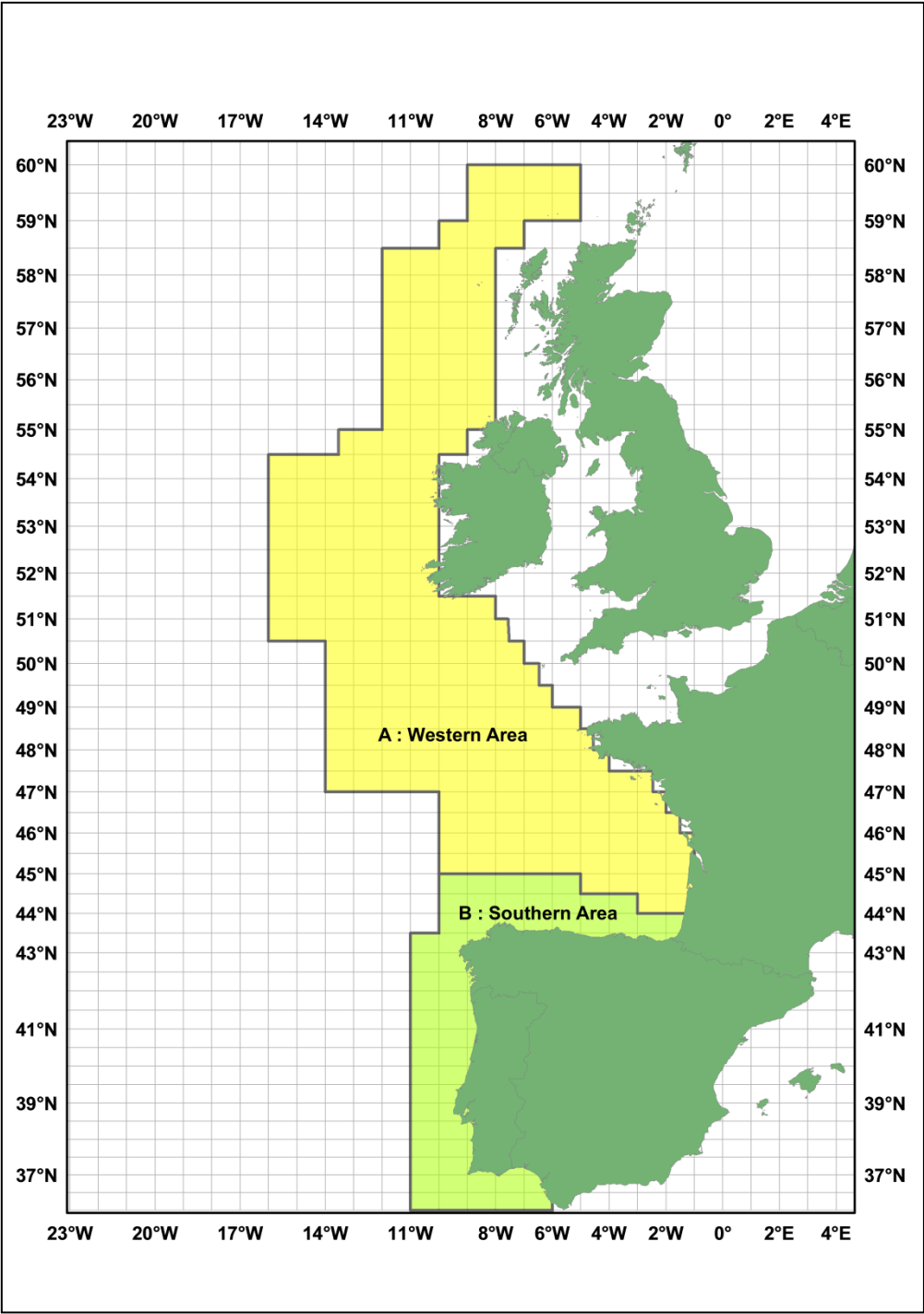


Figure 1.7: Core sampling areas for mackerel eggs in the western and southern areas for 2022. Sampling will be continued outside these limits on surveys based on the adaptive sampling guidelines.

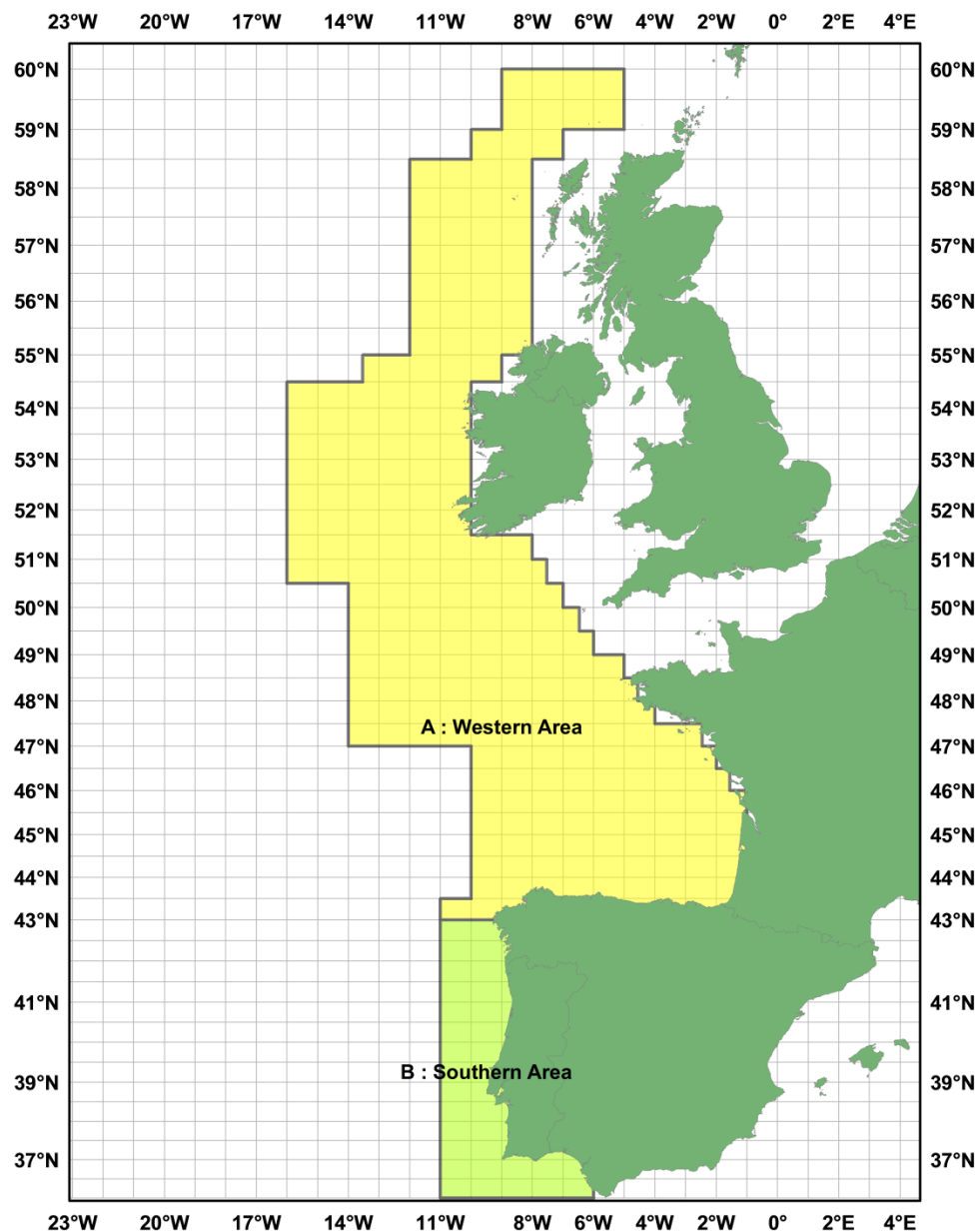


Figure 1.8: Core sampling areas for horse mackerel eggs in the western areas for 2022. Sampling will be continued outside these limits on surveys based on the adaptive sampling guidelines

1.1.4 DEPM survey for southern horse mackerel

IPMA will conduct a DEPM (Daily Egg Production Method) survey for horse mackerel of the Southern stock (ICES division 27.9.a). The DEPM survey will take place during January-February 2022 (provisional dates: 22nd Jan - 22nd Feb), on board RV Vizconde de Eza, covering the area from Gibraltar to Finisterre.

The DEPM survey involves vertical ichthyoplankton sampling, with an adapted CalVET sampler, operating adaptively, on fixed stations, 3 or 6nm apart, along predefined transects, perpendicular to the coast and 12 nm apart, covering the entire continental shelf and upper slope (Figure 1.9). Simultaneously, the

auxiliary CUFES system operates underway (between the CalVET stations), collecting subsurface plankton samples which are sampled and analysed every 3nm. Decisions on the offshore surveying limit are made, adaptively, depending on the samples obtained by the CUFES system. After hauling, ichthyoplankton samples are preserved and subsequently processed and analysed in the laboratory. Concurrently to the plankton sampling with the CalVET and the CUFES, environmental data (temperature and salinity and fluorescence) are recorded.

The plankton samples are then used for: (i) identification and quantification of the target species eggs, per 11 developmental stages; (ii) delimitation and estimation of the spawning area and (iii) estimation of the daily egg production. A detailed description of the standardized methodology is included in the WGMEGS SISP 5 survey manual (ICES 2019a). Data analyses are undertaken using adapted versions of the R packages (geofun, eggsplore and shachar) available at ichthyoanalysis (<http://sourceforge.net/projects/ichthyoanalysis>) and routines developed at IPMA.

The Portuguese survey directed at horse mackerel also provides data (eggs and adult fish) for the mackerel AEPM.

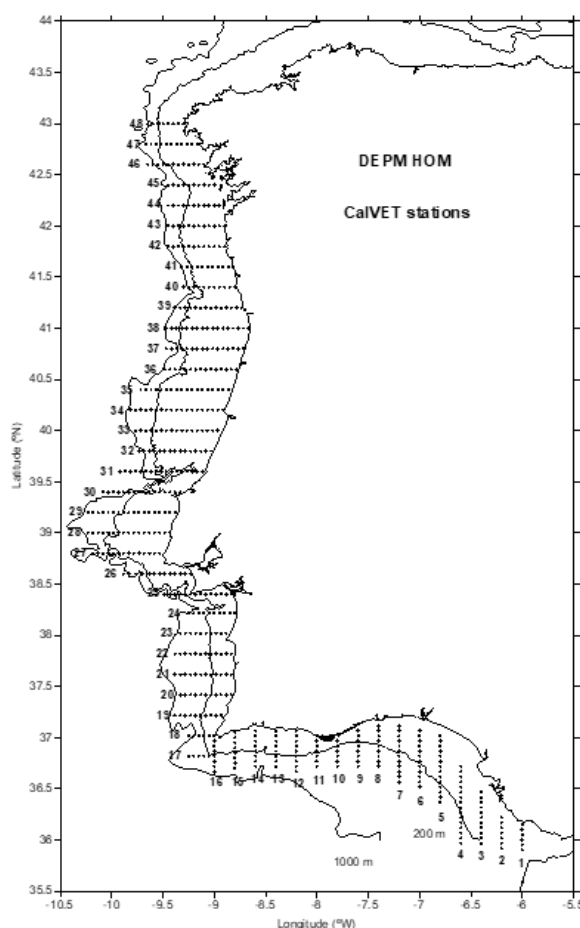


Figure 1.9. Portuguese survey for the southern stock horse mackerel in ICES division 27.9.a; ichthyoplankton CalVET sampling stations.

1.2 Planning of the 2021 mackerel egg survey in the North Sea

WGMEGS planned to conduct a mackerel egg survey in the North Sea in 2020 to estimate egg production and SSB for North Sea mackerel. The Netherlands and Denmark were due to participate in the survey in May and June but due to Covid-19 measures this survey could not be conducted. Instead after consultation with WGWIDE the survey was postponed to 2021 to be conducted by the same two countries (Table 1.3).

Table 1.3 Planned sampling Periods for North Sea mackerel egg survey in 2021.

| Country | Netherlands | Denmark |
|-----------------|------------------|------------------|
| Sampling Period | 25 May – 12 June | 31 May – 11 June |

In 2018 WGMEGS decided to move to a DEPM survey for the North Sea. The reasons for the change included the difficulty in getting potential fecundity samples, recent reduced survey participation which did not allow for full coverage of the spawning area in multiple Periods and the fact that mackerel spawning in the North Sea is contained within specific boundaries (unlike recent shifts seen in the Northeast Atlantic) (ICES, 2018). The plan is to conduct one full coverage of the whole North Sea during the egg survey (Figure 1.10). On each transect a trawl haul will be carried out to collect adult mackerel for biological and ovary samples.

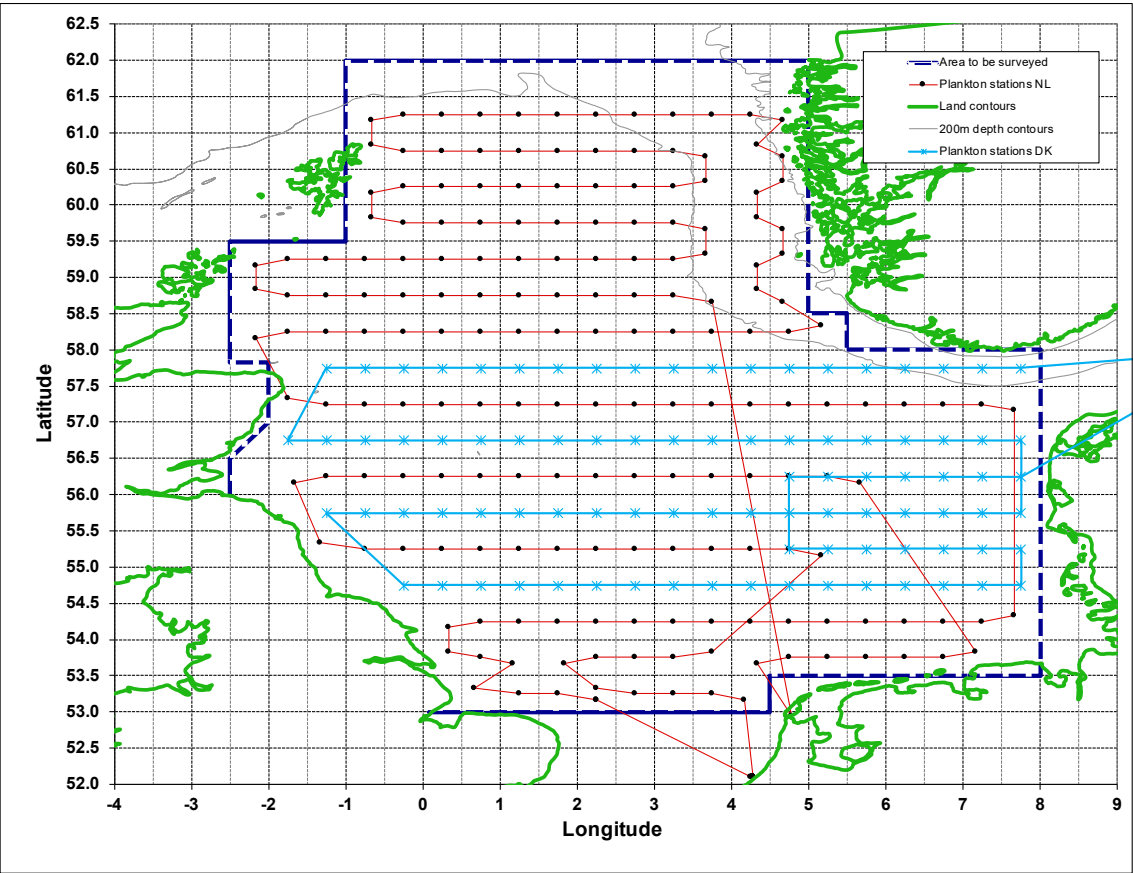


Figure 1.10. Planned plankton sampling for the Netherlands (red line with black squares) and Denmark (blue line with crosses) during the 2021 North Sea mackerel egg survey.

2 Plan and Coordinate the sampling and laboratory analysis for mackerel/horse mackerel fecundity and atresia (ToR b)

2.1 Planning and sampling programme for the mackerel and horse mackerel AEPM and DEPM adult parameters

2.1.1 Sampling for mackerel fecundity and atresia in the Western and Southern areas

The plan for the collection of ovary samples for fecundity and atresia analysis (AEPM) in 2022 is similar to the plan for 2019 (ICES, 2019a). However, in addition to the sampling from the egg survey an attempt will be made to collect additional samples from other surveys that take place in relevant areas during the pre-spawning period. In 2019 MEGS ended up with much lower numbers of pre-spawning fish that could be used for potential fecundity analysis, than planned. By planning to collect extra samples from other surveys in the pre-spawning period, it is hoped the number of potential fecundity samples can be increased.

Tables showing the recommended temporal and spatial distribution of adult fecundity samples for each survey will be included in the updated survey manual prior to the 2022 surveys, and are currently available on the WGMEGS SharePoint. Final recommended sample schedules will be available after the WKAEPM meeting.

2.1.2 Western horse mackerel DEPM adult parameter sampling

Horse mackerel sampling will again be directed at the DEPM method and will be conducted in survey Periods 6 and 7, June and July. Sampling will be carried out as described in the survey protocols (ICES, 2019), but it should be stressed that the directed sampling for hydrated females needs to be taken into account in order to collect enough samples for batch fecundity analyses. This will be highlighted in the survey manual that will be revised at WKAEPM, the Workshop on Adult Egg Production Methods Parameters estimation in mackerel and horse mackerel.

With the low stock size of western horse mackerel, it is increasingly difficult to catch adult horse mackerel and WGMEGS therefore has put out specific requests to other survey groups asking them to collect adult horse mackerel samples from their surveys during May and June 2022.

2.1.3 Southern horse mackerel DEPM adult parameter sampling

Surveying for adult horse mackerel will take place simultaneously with the ichthyoplankton sampling, during peak spawning in ICES division 27.9.a in Periods 2. The plan is to conduct 1-2 fishing hauls, with either pelagic or bottom trawls, per day over the entire survey area. The objective is to obtain a good spatial and temporal coverage, in order to guarantee that fish samples are representative of the population, and subsequently to reduce the bias in the DEPM parameter estimations. A random sample of fish will be selected from each trawl and sampled on-board. Biological information will be recorded, the ovaries collected and preserved for histology, and the otoliths removed for ageing. Extra effort will be placed

to obtain spawning females for batch fecundity estimation. On-board sampling will be complemented with fish from commercial vessels, obtained at four or five ports along the Portuguese coast during the Period of the survey. The sampling protocols for these samples will be adapted according to the facilities at the ports.

The biological data will be used to estimate the mature fraction of the population and to estimate the sex ratio, female mean weight and mean female expected batch fecundity for each haul. The preserved gonads will be used to assess the mature/immature condition of females, to measure individual batch fecundity, and to estimate the daily spawning fraction. Data analyses and the DEPM parameter estimations will be performed using R routines developed at IEO. A detailed description of the methodology can be found in WGMEGS SISP 5 (ICES, 2019a).

2.1.4 DEPM sampling for mackerel

During the three most recent egg surveys (2013, 2016 and 2019) additional biological samples were collected to implement the Daily Egg Production Method (DEPM). (ICES, 2012b; ICES, 2012a; ICES, 2015; ICES, 2018). This additional sampling will again be undertaken during the 2022 survey and will provide the fourth point of a five-point data series. WGWIDE will require a five-point time series as a minimum in order to consider using SSB calculated by DEPM rather than AEPM in its assessment process (ICES, 2012b, ICES, 2012).

Adult samples for DEPM will be taken during the mackerel peak spawning in March - April. The definitive planning of the DEPM periods will be prepared at WKAEPM in November 2021. The sampling schedule will be the same design as for the previous survey 2019 (ICES, 2019b) which will be included in the survey manual prior to the 2022 surveys.

During the WKAEPM 2021, the adult sampling protocol for DEPM will be reviewed. Since the manual is unclear regarding some of the issues that were discussed during the WGMEGS meeting, these must be discussed in the WKAEPM and clarified in the revised manual. Especially the need to sample additional numbers of hydrated females for the estimation of batch fecundity.

3 Review and update the manuals for the Mackerel and Horse Mackerel Egg Surveys and fecundity estimation (Tor c,d)

3.1 Review procedures for egg sample sorting, species ID, staging, data submission and subsampling (ToR c, e) including update of manual

The procedures for egg sample sorting, species ID, staging, data submission and sub-sampling were reviewed and published in 2019 as a new version, 2.2, of SISP 6 (ICES 2019).

During the 2021 WGMEGS meeting the manual was quickly reviewed and its publication in the new ICES TIMES format discussed.

- It was decided that for the coming survey in 2022, the manual only needs a small number of minor amendments or corrections, and shall otherwise be kept as the standard survey manual. The annexes, however, will be updated with the plans for the 2022 survey.
- At the end of this WGMEGS term in 2023, an updated and revised manual in the new TIMES format will be submitted to ICES for publication.

The following major amendments will be included in the new manual:

- Updated maps of standard survey areas for three target species: mackerel, horse mackerel and hake
- A chapter on the utilization of new techniques for sample workup including image analysis, and species identification using molecular analysis (DNA and/or proteomics);
- A chapter on data flow and management.

From 11th to 15th October 2021, WGMEGS will organize the Workshop on Mackerel, Horse Mackerel and Hake Egg Identification and Staging (WKMACHIS), chaired by Matthias Kloppmann (Germany). WGMEGS recommends that this workshop will be held as a physical meeting in Bremerhaven. Besides the usual visual exercises on egg identification and staging, the use of image analyzing techniques will also be practiced.

3.1.1 Survey boundaries rule

Due to the recent expansion in mackerel distribution in May / June, and the difficulty in ensuring full sampling coverage of this expanded area, WGMEGS is considering a change to the rule allowing for a transect change. In past MEGS surveys a transect change occurred on the basis of two consecutive zero samples of mackerel or horse mackerel. In more recent years this was amended to allow a transect change after a number of stations of consistent low egg counts. There is a recommendation from WGMEGS to WKMACHIS to clarify what this “low” number should be.

During the 2016 and 2019 surveys concerns were raised that WGMEGS was underestimating SSB by not getting zero stations on the western end of transects in the west and northwest, particularly in May and June. Exploratory surveys carried out in 2017 and 2018 showed that while transect boundaries were not delineated, any missed production from this area did not contribute significantly to overall SSB.

3.2 Review and update the manuals for the Mackerel and Horse Mackerel Egg Surveys and fecundity estimation

During the WGMEGS meeting April 2021 the current manual for the Mackerel and Horse Mackerel fecundity and atresia analysis was discussed. The conclusion was that the manual only needs small adjustments, and that these will be revised at the WKAEPM, in November. However, it was also decided that at this point information on the correct histology cassettes to use for the collection of screening samples should be disseminated. The cassettes prevent cross contamination of samples and also prevents the ovary slice from severe disintegration.

To complement the text and pictures contained in the fecundity manual, it was decided to prepare a reference collection of digital histological slides of mackerel and horse mackerel. This reference collection will assist in standardizing the histological analysis for screening, atresia and POF's.

The work on the descriptions and scripts for the fecundity and atresia estimations, as well as the DEPM calculations will be continued, in order to review these during the WKAEPM and add these to the revised manual.

The fecundity manual is to be revised and reorganised according to the TIMES format for delivery to ICES in 2023.

4 MEGS biological and fecundity database

Egg data

In 2012 WGMEGS began discussions with ICES about including current and historic survey data in the ICES egg and larval database, to make it publicly available. This data would include station data as well as egg identification and staging data. After careful consideration WGMEGS decided that historical data from the Western and southern surveys as far back as 1992 was of sufficient quality to be included in the database. This was initiated subsequent to a change in the development equation (from Lockwood et al 1977 to Mendiola et al 2006) used to estimate mackerel egg abundance. This change required a recalculation of the entire historic egg abundance time-series back as far as 1992. During 2013 and 2014 Finlay Burns and Gersom Costas cleaned and reformatted the individual survey data files into a coherent and standardised format that would enable easy transfer into the ICES input format. The first version of the historic egg data was uploaded in December 2014 but during subsequent years amendments were made to the database format resulting in a further submission being required and so in early 2019 all the egg data from 1992 to 2018 in the southern and western areas was uploaded to the [ICES egg and larvae database](#). As well as the triennial survey data this also included the additional exploratory surveys undertaken in the interim years such as those in 2017 and 2018, and the winter / spring surveys of 2014 / 2015. Work is currently ongoing to incorporate data from the North Sea surveys into the required format.

Fecundity and Atresia database

During the egg survey adult females are collected for fecundity and atresia analysis. However, in addition to this data, biological parameters are collected from the catch of mackerel and horse mackerel. These data have previously not been stored in a central database, but are used for the assessment and advice provided by ICES. Therefore, it was recommended that a data base was set up to ensure the standardized transmission of the biological, fecundity and atresia data and public availability of the data. Both the fish and the fecundity and atresia data will be stored in a relational database with several tables, which will be hosted by ICES.

The egg data are collected separately from the fish and fecundity and atresia data, but for the estimation of the spawning stock all these datasets are needed. It is therefore recommended that both the Egg and Larvae database and the Fish, Fecundity and Atresia databases should be accessible via one data portal.

The historical fish data back to 1986 has recently been collated by Thassya dos Santos Schmidt from the various national databases and are now unified into a single Excel file. The historical fecundity and atresia data have also been gathered back to 2001 (2004 data is not available) and exists as three Excel files; fecundity, intensity of atresia, and prevalence of atresia.

Following discussions at WGMEGS meetings and additional meetings between WGMEGS members and the ICES data centre, a format has been suggested based on existing ICES databases and datasheets used by WGMEGS for reporting of fecundity and atresia data. The working title of the ICES database is: Fish Reproduction portal, Fecundity and atresia database.

It is also planned that the historic data on fish, fecundity and atresia (from 1986 to 2016) will be included in this database. However, some of the older fecundity and atresia datasets may not fit well with the new database format. The ICES data centre has agreed to providing the possibility for a historic data format to ensure the historic data (in line with the historic data format for the ICES egg and larvae database).

Data related to the DEPM method (POF's, oocyte hydration, batch fecundity) is planned to be put in separate tables within the database. These data go back to 2013.

Currently, the proposed format is being reviewed by WGMEGS. The ICES data centre is planning to have the database ready for use in 2021.

For the 2022 survey, WGMEGS advises that all additional biological data from adult mackerel and horse mackerel should be sent, as soon as the samples are processed after the individual surveys, to the biological sampling coordinator (jens.ulleweit@thuenen.de) with the agreed data entries following the format of the Fish Reproduction portal, Fecundity and atresia database.

5 Shift from North Sea mackerel egg survey to the same year as the Atlantic survey

Since 1982 the North Sea has been surveyed one year after the western and southern surveys take place. Historically this survey was carried out by Netherlands and Norway. In more recent years, due to the withdrawal of Norway, it has been undertaken by Netherlands on their own. Since the withdrawal of Norway the Netherlands has also added additional effort to this survey.

During the 2020 WGMEGS meeting, (ICES 2021), it was reported that WKRRMAC, the Workshop on a Research Roadmap for Mackerel, (ICES 2019), felt that there was little benefit in surveying the western waters and the North Sea in separate years. They said better justification was needed to maintain this practice.

Also at the 2020 WGMEGS meeting a review was carried out of recent survey effort and requirements to survey in both the western and North Sea areas. This led to a number of questions being asked of MEGS participants. Prior to the 2021 WGMEGS meeting a questionnaire was circulated to WGMEGS participants seeking information on a number of issues. One of these questions was the availability of effort to conduct the North Sea survey in the same year as the western survey, in light of the new involvement of Denmark and the possible return of England. A summary of these results are available on the WGMEGS SharePoint.

Denmark participated on the North Sea survey for the first time in 2021. England have indicated they are interested in returning to the MEGS group and would also be willing to survey in the North Sea. However both these countries have indicated that they would be unable to participate on the western surveys. Prior to these two new participants coming on-board WGMEGS was not in a position to consider moving the timing of the survey. Now however the group feel that there is sufficient vessel coverage available to conduct the North Sea survey in the same year as the western survey. The western area survey will have similar effort available to it as in recent years.

Prior to making any change to the North Sea survey timing WGMEGS contacted WGWISE to ensure that the proposed timing change would not have any significant impact on the mackerel assessment. WGWISE responded to say that as long as changing the timing of the North Sea survey didn't have any impact on the effort available to the western survey they felt that changing the North Sea survey timing would be an improvement.

In 2018 WGMEGS, (ICES 2018), decided that future North Sea surveys would be DEPM style surveys rather than AEPM. The DEPM survey would only require one full coverage of the spawning area over a shorter time period. However, this method also requires a large number of adult samples to be collected and analysed. In their recent communication WGWISE asked WGMEGS to produce a working document for the WGWISE meeting in August 2021 explaining the rationale for this change in survey design.

No full consensus was reached amongst participants, but WGMEGS now propose to conduct the North Sea survey in May / June 2022. They propose that the survey will be carried out by Denmark and England, and will follow a similar design to the 2021 survey. England will contribute 24 days vessel time while Denmark will contribute 12 days. As this change to the timing of the survey will have an impact on the national work plans of some MEGS participants it is probable that the proposed change in survey timing will be subject to a review at the EU Regional Coordination meeting before it can be implemented.

6 Evaluation of sampling strategies

Two important factors need to be considered when planning survey sampling strategy. Firstly, a set of rules must be established to decide when to stop sampling along a given transect, in order to ensure that the whole area of egg distribution is sampled. Secondly, some guidelines need to be provided on the number and spacing of transects which may be omitted in order to best match available effort to the size of the area to be surveyed (ICES. 2019b).

During survey Periods when several ships are available it should be possible to sample all transects, while at other times it may be necessary to omit several, at least during the first pass over the designated sampling area. No more than one consecutive transect should ever be omitted, however. It is also recommended that even where total coverage is expected, a first pass over the area should be made on alternate transects, picking up the intervening transects on the return leg (ICES. 2019b).

Since the 2007 survey a continuing expansion of the mackerel spawning area and season has been observed (ICES, 2020). As a result of this large expansion, and the limited available ship time, it has frequently become necessary to sample alternate transects, without sampling the intervening transects on the return leg, in order to cover the entire spawning area and delineate of the spawning boundaries (ICES. 2018).

In order to test possible effects of the use of interpolating alternate transects in the estimation of egg production by Period, some analysis has previously been presented at WGMEGS and WGSDAA meetings (ICES, 2015, ICES 2015b). These analyses showed that there can be a significant impact in the calculation of egg production by Period when some transects are removed and replaced by interpolated transects. These works concluded that this impact was because the daily egg production presented high space-time variability in Period.

A new analysis was presented during the 2021 WGMEGS meeting showing that time, (using week as unit time), has a significant impact in the interpolated value of daily egg production on unsampled rectangles caused by egg production in neighbouring sampled rectangles. This bias in interpolated rectangles could consequently affect the estimate of egg production by Period.

A consequence effect of having sampled significant survey area in a short period of time, (1 week), during a survey Period (duration about 4 weeks), could be the increase of uncertainty in the estimate of total egg production in that Period and therefore in total annual egg production. AEPM provides an integrated view of egg production during the spawning season rather than the snapshot provided by DEPM surveys (Stratoudakis, 2006, Takasuka, 2018),

As a possible solution could be that certain Periods, whenever possible, survey coverage by some countries could overlap each other. One country could do a first pass on alternate transects, with a second country sampling the intervening transects in a different time (week) in the overlapped area. This way we could ensure a decrease of uncertainty of Daily egg production during a survey Period and an adequate coverage of spawning area in a Period which could address unforeseen events (poor weather, equipment failure, vessel breakdown)

7 Western horse mackerel egg surveys

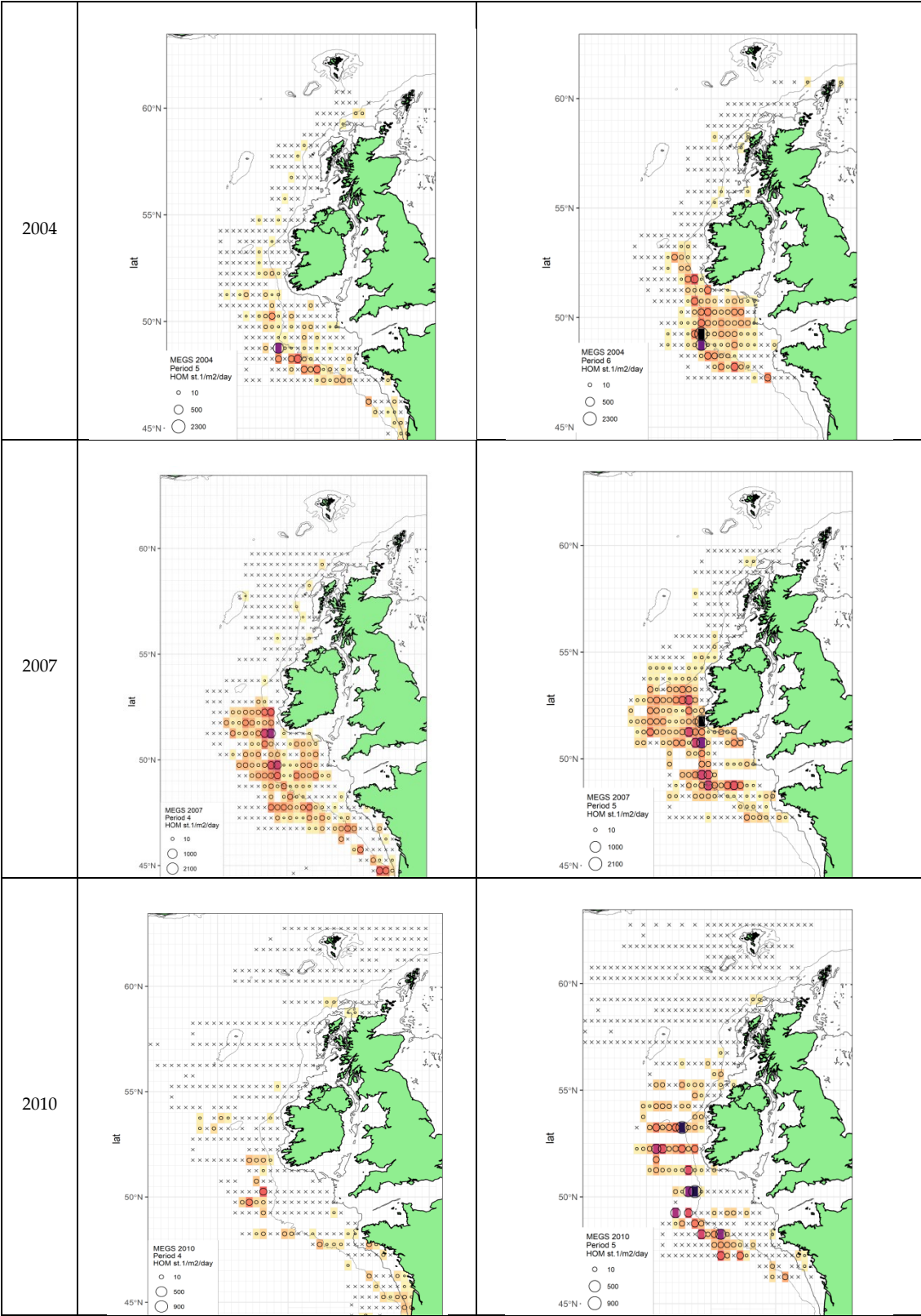
In 2019 horse mackerel egg production was the lowest recorded in the time series since 1992. Peak spawning occurred in July, the last sampling period of the egg survey. In 2013 and 2016 peak horse mackerel egg production was also found to have taken place in July. As a result of the 2013 survey an extra sampling period was added to the egg survey in August 2016 (ICES, 2017). Horse mackerel egg production in August 2016 was very low however, confirming the peak of egg production in early July, and therefore it is assumed that no substantial horse mackerel egg production was missed in 2016. Prior to 2013 peak egg production was normally found to take place in June.

In 2019 the egg production peak in the first half of July was much lower compared to 2016 and 2013. In addition, only 3% of the females caught for fecundity estimate in July showed signs of recent spawning.

During the 2020 WGMEGS meeting it was discussed whether this low level of egg production in last few years could be an indication of horse mackerel spawning having shifted later in the year (ICES, 2021).

At the 2021 WGMEGS meeting survey maps of observed horse mackerel egg densities during peak spawning (June- July), from 2004 onwards, were analysed (Figure 5.1). It was noticed that since 2010 alternate transects were sampled during later survey Periods (which coincides with peak spawning in horse mackerel), with the aim of covering the whole spawning area. In addition, it was noticed that some stations can have high densities of horse mackerel eggs, but stations on either side may contain low egg densities or no eggs (Figure 7.1). This could indicate that egg distribution has been patchier in recent years. Since the distribution of eggs is appearing patchier, the distance between sampling stations could be narrowed to ensure more accurate data collection.

As a result of the increased use of alternate transects and the patchier distribution of horse mackerel eggs in last few surveys, there could have been a substantial impact on the bias of horse mackerel egg production. This patchier distribution of eggs could also be an effect of a shrinkage in time and space of the horse mackerel spawning season due to the poor status of the western area horse mackerel stock in recent years (ICES, 2020)



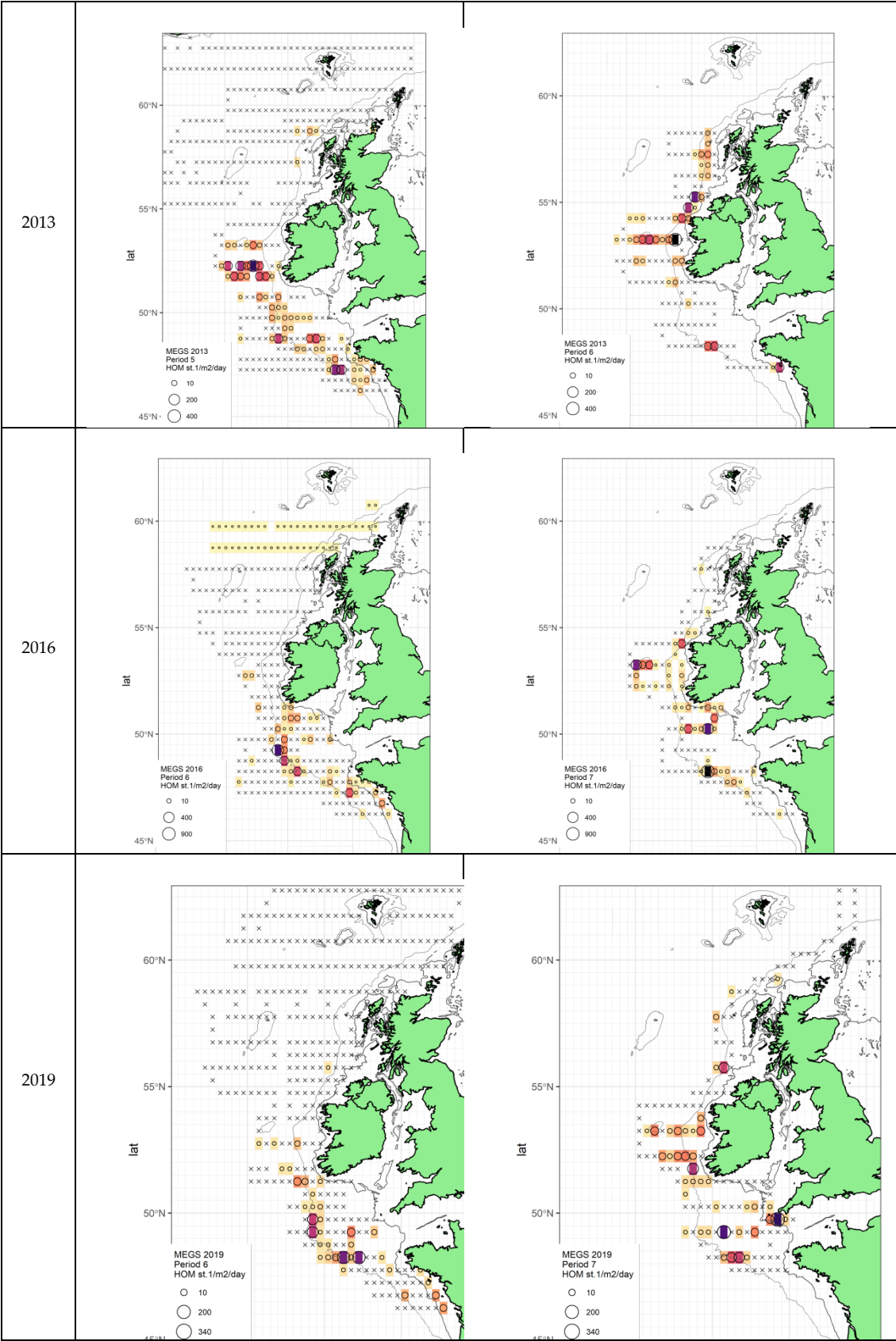


Figure 7.1. Observed horse mackerel egg production by half rectangle for peak spawning since 2004 to 2019

8 Exploratory egg survey in 2021

WGMEGS plans to conduct an exploratory egg survey in the Northern North Sea and up and along the Norwegian Shelf in June 2021 to map the distribution of spawning mackerel within these Northern areas and it is hoped that the results will inform the planning process for the triennial MEGS survey in 2022. The survey will take place onboard the MFV Altaire between the 7th – 22nd June 2021. In addition to the exploratory objective, the proposed survey will also contribute 2 ichthyoplankton survey transects that will feed into the North Sea MEGS survey currently being undertaken by the Netherlands and Denmark. The intention will be to also collect adult samples in this area, using a pelagic trawl, that will also feed into the DEPM fecundity process in the North Sea (see Figure 8.1).

During the last NEA mackerel benchmark in 2017 (ICES, 2017), and as part of the WGMEGS survey review process, a commitment was made to undertake exploratory ichthyoplankton surveys within the mackerel spawning boundary regions in the North and Northwest. These are areas where, in recent years, MEGS surveys have struggled to delineate a hard spawning boundary. During 2017 and 2018 exploratory surveys undertaken by Ireland and Scotland, utilising Gulf 7 samplers, successfully mapped and delineated a mackerel spawning boundary within the offshore areas of Hatton Bank/South Iceland Basin and the Scotland-Faroe-Iceland Ridge. The results from these surveys played a useful role in informing the survey planning process ahead of the 2019 MEGS triennial survey. The Norwegian Shelf however was an area that still provided a level of uncertainty, especially with recent MEGS survey results providing compelling evidence (ICES, 2021) that mackerel appear to be favouring this North-eastern route as they head North to their summer feeding grounds. This survey aims to conclude these exploratory objectives by surveying mackerel spawning activity along the Norwegian Shelf during the month when the highest mackerel spawning densities are likely to be encountered within this region. Results from the 2019 MEGS survey also confirm this. Additional trawl samples will also be collected to progress ongoing research taking place at IMR, Bergen. The survey results will be provided to WGMEGS in time to feed into the planning process of the triennial MEGS survey in 2022.

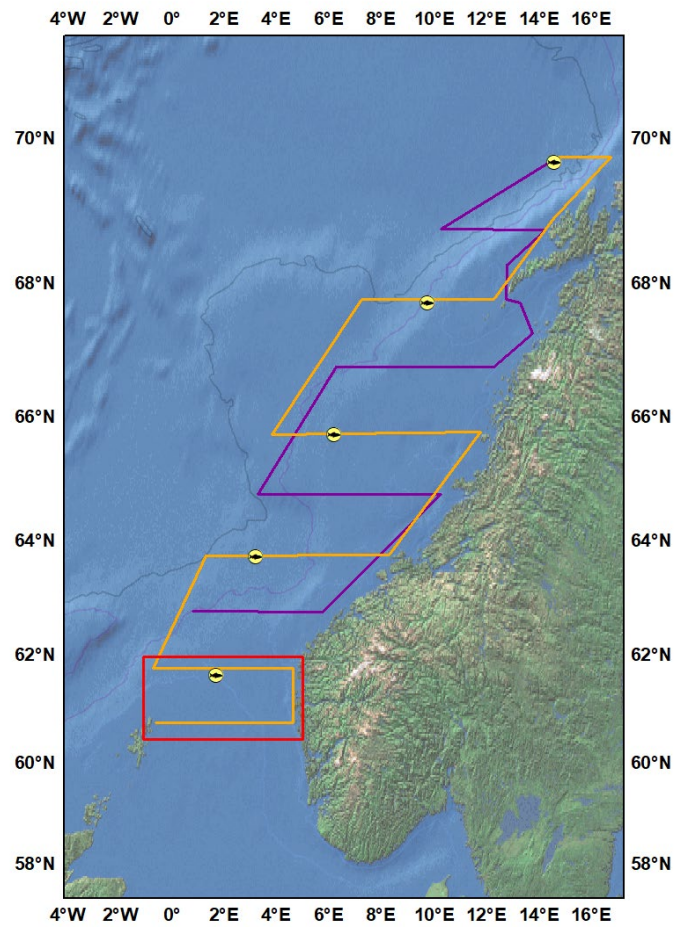


Figure 8.1. Map showing potential outbound (orange) and inbound (purple) cruise tracks for survey 0321H. Transects enclosed within the red box denote area being surveyed as part of the North Sea MEGS. Fish icons denote potential trawl stations although these are indicative only with actual trawl locations being determined by the presence of mackerel or mackerel eggs in the water column.

9 References

- ICES. 2012a. Report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS), 18-21 April 2012, Galway, Ireland. ICES CM 2012/SSGESST:04. 135 pp.
- ICES. 2012b. Report of the Workshop on Survey Design and Mackerel and Horse Mackerel Spawning Strategy (WKMSPA), 16-17 April, Galway, Ireland. ICES CM 2012/SSGESST: 05, 32 pp.
- ICES. 2012c. Report of the Workshop on Survey Design and Mackerel and Horse Mackerel Spawning Strategy (WKMSPA), 16-17 April, Galway, Ireland. ICES CM 2012/SSGESST: 05, 32 pp.
- ICES. 2015a. First Interim Report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS), 20-24 April 2015, ICES Headquarters, Copenhagen. ICES CM 2015/SSGIEOM:09. 66 pp.
- ICES. 2015b. First Interim Report of the Working Group on Improving use of Survey Data for Assessment and Advice (WGISDAA), 20-22 January 2015, ICES HQ, Copenhagen, Denmark. ICES CM 2015/SSGIEOM:28. 24 pp.
- ICES. 2017a. Final Report of the Workshop Group on Mackerel and Horse Mackerel Egg Surveys. ICES CM 2017/SSGIEOM: 18.
- ICES. 2017b. Report of the Benchmark Workshop on Widely Distributed Stocks (WKWIDE), 30 January-3 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:36. 196 pp.
- ICES. 2018. Report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS). ICES CM 2018/EOSG: 17.
- ICES. 2019a. Manual for the AEPM and DEPM estimation of fecundity in mackerel and horse mackerel. Series of ICES Survey Protocols SISP 5. 89 pp. <http://doi.org/10.17895/ices.pub.5139>
- ICES. 2019b. Manual for mackerel and horse mackerel egg surveys, sampling at sea. Series of ICES Survey Protocols SISP 6. 82 pp. <http://doi.org/10.17895/ices.pub.5140>
- ICES. 2019c. Workshop on a Research Roadmap for Mackerel (WKRRMAC). ICES Scientific Reports. 1:48. 23 pp. <http://doi.org/10.17895/ices.pub.5541>
- ICES. 2020. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 2:82. 1019 pp. <http://doi.org/10.17895/ices.pub.7475>
- ICES. 2021. ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS: outputs from 2020 meeting). ICES Scientific Reports. 3:11. 88pp. <https://doi.org/10.17895/ices.pub.7899>
- Lockwood, S. J., Nichols, J. H., and Coombs, S. H. 1977. The development rates of mackerel (*Scomber scombrus* L.) eggs over a range of temperature. ICES CM 1977/J:13, 8 pp.
- Mendiola, D., Alvarez, P., Cotano, U., Etxebeste, E., and Martinez de Murguia, A. 2006. Effects of temperature on development and mortality of Atlantic mackerel fish eggs. *Fisheries Research*, 80: 158-168.
- Stratoudakis, Y., Bernal, M., Ganas, K., Uriarte, A., 2006. The daily egg production method: recent advances, current applications and future challenges. *Fish Fish.* 7, 35-57.
- Takasuka A, Yoneda M, Oozeki Y (2019) Density dependence in total egg production per spawner for marine fish. *Fish Fish* 20: 125-137.

Annex 1: List of participants

| Name | Institute | Country (of institute) | Email |
|----------------------------|-----------|------------------------|----------------------------------|
| Paula Alvarez | AZTI | Spain | palvarez@azti.es |
| Maria Manuel Angelico | IPMA | Portugal | mmangelico@ipma.pt |
| Ewout Blom | WUR | The Netherlands | ewout.blom@wur.nl |
| Finlay Burns | MARLAB | Scotland | F.Burns@marlab.ac.uk |
| Gráinne Ní Chonchúir | MI | Ireland | grainne.nichonchuir@marine.ie |
| Gersom Costas (Chair) | IEO | Spain | gersom.costas@ieo.es |
| Cindy van Damme | WUR | The Netherlands | cindy.vandamme@wur.nl |
| Sólva Eliassen | FAMRI | Faroe Islands | Solvae@hav.fo |
| Merete Fonn | IMR | Norway | merete.fonn@hi.no |
| Dolores Garabana | IEO | Spain | dolores.garabana@ieo.es |
| Hannah Holah | MARLAB | Scotland | Hannah.Holah@gov.scot |
| Bastian Huwer | DTU | Denmark | bhu@aqua.dtu.dk |
| Matthias Kloppman | TI | Germany | matthias.kloppmann@thuenen.de |
| Maria Korta | AZTI | Spain | mkorta@azti.es |
| Richard Nash, | CEFAS | England | richard.nash@cefas.co.uk |
| Cristina Nunes | IPMA | Portugal | cnunes@ipma.pt |
| Ismael Nuñez-Riboni | TI | Germany | ismael.nunez-riboni@thuenen.de |
| Anna Olafsdottir | MFRI | Iceland | anna.olafsdottir@hafogvatn.is |
| Brendan O'Hea (Chair) | MI | Ireland | brendan.ohea@marine.ie |
| Carlos Pinto | ICES | | Carlos.pinto@ices.dk |
| Isabel Riveiro | IEO | Spain | isabel.riveiro@ieo.es |
| Joana Ribeiro | ICES | | joana.ribeiro@ices.dk |
| Thassya dos Santos Schmidt | IMR | Norway | thassya.dos.santos.schmidt@hi.no |
| Anders Thorsen | IMR | Norway | anders.thorsen@hi.no |
| David Tully | MI | Ireland | david.tully@marine.ie |
| Jens Ulleweit | TI | Germany | jens.ulleweit@thuenen.de |
| Kai Wieland | DTU | Denmark | kw@aqua.dtu.dk |

Annex 2: Resolutions

2020/FT/EOSG01 **A Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS)**, chaired by Gersom Costas*, Spain and Brendan O’Hea*, Ireland, will work on ToRs and generate deliverables as listed in the Table below.

| | Meeting dates | Venue | Reporting details | Comments (change in Chair, etc.) |
|-----------|---|-------|--|--|
| Year 2021 | 26–30 April | TBD | Interim report by 14 June 2021 to ACOM/SCICOM | Brendan O’Hea and Gersom Costas confirmed as new chairs. |
| Year 2022 | WebEx after the survey and prior to WGWide meeting of the same year | | Interim report by 30 September 2022 to ACOM/SCICOM | second meeting of group via correspondence and remotely as WebEx conference as it falls within the year of the triennial MEGS Survey. The date for report delivery is set after the WGWide meeting to be able to include the preliminary results of the 2022 survey. |
| Year 2023 | April | tbd | Final report by 12 June 2023 to ACOM/SCICOM | |

WGMEGS ToRs 2021 – 2023

| ToR | Description | Background | Science Plan Codes | Duration | Expected Deliverables |
|-----|---|---|------------------------------------|---------------|---|
| a | Plan and coordinate the Mackerel/Horse Mackerel Egg Surveys in the ICES areas 4 to 9. | The egg surveys in the Northeast Atlantic (ICES areas 5 to 9) and in the North Sea (ICES area 4) provide important data for fishery-independent stock indices for Northeast Atlantic mackerel and for both the western and the southern horse mackerel stocks. The survey is part of a time-series that commenced in 1977. With up to 10 nations and up to 18 individual cruises participating in the survey, careful and detailed planning and coordination of the surveys is essential. | 3.1 | years 1 – 3 | Continuously updated survey plans and survey summary sheets of the surveys in 2022/23 on the WGMEGS share-point |
| b | Plan and Coordinate the sampling and laboratory analysis for mackerel/horse mackerel fecundity and atresia. | Reliable realized fecundity estimates are needed to convert the egg abundance data to SSBs. International coordination is needed to ensure that the samples collected on different survey are representative and collections efficient. | 3.1 | Year 1, 2 & 3 | Coordinated Sampling Plan for the surveys in 2022/23 on the WGMEGS share-point |

| | | | | | |
|---|---|---|------------------------------------|-----------------|--|
| c | Review and update the manuals for the Mackerel and Horse Mackerel Egg Surveys and fecundity estimation | Well defined, standardized sampling and laboratory procedures are necessary to properly interpret the monitoring data as well as ensuring that rigorous and transparent QAQC procedures have been applied and can be evaluated by external reviewers. | 3.1, 3.2 | Year 1, 2 and 3 | Updated manuals for both, egg surveys and fecundity estimation for WGMEGS on the sharepoint in years 1 and 2, for publication in TIMES in year 3 |
| d | Coordinate the quality-controlled data delivery to the ICES databases for both, egg abundance and fecundity data | x | 3.1 | Year 3 | Updated ICES egg and larval database. ICES fecundity and atresia database |
| e | Organise and evaluate workshops aimed at developing survey specific expertise in fish egg identification and staging, and fecundity estimation | For quality assurance in the year before the Atlantic survey two workshops will be organized in which survey participants are obliged to participate in order to standardize egg identification and staging and fecundity estimation. The WGMEGS manual is required to be updated with the results from those workshops. | 3.2, 3.3 | Year 1 and 2 | TIMES survey manual article |
| f | Prepare, organise and evaluate a workshop on mackerel and horse mackerel survey design and data quality assurance and control | Since the recent surveys and due to rapidly changing environmental conditions, the assumptions, under which the current survey design was determined, are being increasingly challenged. New survey strategies and techniques, as well as new methods for spatial data analysis need to be carefully implemented in order to maintain the integrity of the time series. | 3.2, 3.3 | Year 3 | CRR |
| g | Provide relevant fisheries resources assessment groups with quality-controlled time series of indices on spawning stock biomass for mackerel, horse mackerel and hake in time fore the assessments. | Provisional estimates of mackerel SSB, and egg production of horse mackerel and hake are delivered in the year of the survey. The estimates however are finalized during the WGMEGS meeting in the year after the Atlantic survey. | 1.3, 3.1, 5.1, 5.2 | Years 2 and 3 | |

Summary of the Work Plan

| | |
|--------|--|
| Year 1 | Planning of the egg survey in 2022, conduct 2 workshops to develop survey specific expertise |
| Year 2 | Survey year, the Atlantic survey is conducted in 2022, a WebEx meeting will take place in year 2 after the survey to collate the survey results and provide preliminary results. A report, by correspondence, with the updated planning and manuals, and the preliminary results of the 2022 survey, is published. |
| Year 3 | Reporting and finalizing of the results of the 2022 egg survey. Planning of the 2023 North Sea egg survey. Delivery of CRR on mackerel and horse mackerel survey design. |

Supporting information

| | |
|-----------------------|---|
| Priority | Essential. The egg survey provides important fishery-independent stock data used in the assessment for Northeast Atlantic mackerel and for the western horse mackerel stocks. |
| Resource requirements | No additional resources needed for ICES. For participants the surveys are all part of the national programs. The surveys and associated meetings are also partially funded under the EU fisheries data directive. |
| Participants | Usually ca. 15–20 participants from ICE, Far, N, NL, P, ESP, UK (E), UK (Scot), DE, DK, IRL. |

Annex 3: Abstracts of presentations given during the WGMEGS meeting

New calculation of annual egg production from the ICES Mackerel Egg Survey

Ismael Nunez et al.

Thuenen-Institute of Sea Fisheries, Bremerhaven, Germany

The traditional calculation of the TAEP uses individual observations of daily egg production (DEP), independently if they are extreme, seldom observed values. In the few sampling cells with replicas, the DEP is estimated as the arithmetic average of all replicas. Estimates of DEP for cells which (due to weather conditions) could not be sampled, are obtained from the arithmetic average of neighboring cells (i.e. meaning a spatial interpolation data). Since 2007, the mackerel spawning area has been expanding towards the northeast. To cope with this expansion but keeping the survey effort and cost unchanged, fewer replicas have been taken and more cells have remained unsampled, increasing the amount of interpolated DEP estimates. Motivated by obtaining more accurate DEP estimates, we propose an alternative method to calculate the TAEP. We apply a generalized additive model (GAM) with logarithmic link and Tweedie distribution to individual DEP values of both western and southern Mackerel components. A GAM has been applied to data in each individual annual survey. Variables tested have been longitude, latitude Julian day, temperature (ECMWF Ocean Reanalysis System, ORAS5), bathymetry (ETOPO1) and the spatial gradient of bathymetry. Once the model was fitted, DEP was predicted on the nodes of the sampling grid. Only nodes inside a convex hull defined by all observations with a Delaunay triangulation were used to avoid extrapolating DEP beyond the survey limits, reducing GAM "edge effects". The DEP is then integrated in space and time following the traditional method. Various models with different combinations of variables and model terms, including interactions between variables, were tested. To choose the best model, we calculated the average Akaike Information Criterion over all years and the root mean square differences between our TAEP and the traditional method, as well between our TAEP and a scaled Spawning Stock Biomass index. Our results show multi-year trends similar to those in the traditional method, but with a TAEP roughly 4×10^{14} eggs/(day·m²) lower. This difference seems to arise because extreme DEP values (which are better handled with the GAM) are one order of magnitude larger than the commonly observed DEP values. Therefore, the traditional method could systematically overestimate the real TAEP.

Progress of WGMEGS work at WGISDAA

Matthias Kloppmann

Thuenen-Institute of Sea Fisheries (Thunen, Germany)

With its 2014 final report, WGMEGS issued a recommendation to WGISDAA to look into the design of the triennial survey w.r.t. to the increasing use of alternate transect design, where every other transect was omitted in order to cover the increasing spawning area of mackerel. Cooperation between WGMEGS and WGISDAA started in 2015 and has since been continued. Major focus was put on the design of NEA Survey and TAEP calculation w.r.t. the increasing amount of interpolation in the 2 components, a new approach for estimating total annual egg production using GAMs, sensitivity analysis of SSB index calculation to different parameters used in fecundity estimation, the possible transition to daily egg production method, and the time series of the North Sea survey. During this cooperation WGMEGS received advice from WGISDAA: in order to achieve an unbiased estimate of mackerel TAEP sampling effort should be prioritized in the core spawning areas and also the double zero rule, which is currently utilized for the decision on terminating a transect, should be reviewed. Furthermore, it was recommended that a modelling approach should be considered to explore spatial and temporal variability of egg production. For

the possible impact of the change from AEPM to DEPM on the assessment, WGMEGS was advised to communicate with WGWISE. Also, revision of the objectives of the North Sea MEGS was recommended.

WGMEGS will continue its cooperation with WGISDAA while further developing the GAM for EP estimation and continuing the sensitivity analysis on impact of fecundity on SSB estimation.

Norwegian Shelf Exploratory egg survey 2021

Finlay Burns

Marine Scotland Science (MSS, Scotland)

During the last NEA mackerel benchmark in 2017 and as part of the WGMEGS survey review process a commitment was made to undertake exploratory ichthyoplankton surveys within the mackerel spawning boundary regions in the North and Northwest and where the MEGS surveys have hitherto struggled to delineate a hard spawning boundary. Mackerel spawning within these offshore regions was first reported back in 2007 but only at relatively low levels. The 2016 MEGS survey delivered a significant change to this situation with peak spawning taking place over a broad swathe of open ocean to the West and Northwest of Scotland, far away from the traditional spawning hotspots and uncomfortably close to the Northern and northwestern survey boundary. During 2017 and 2018 exploratory surveys undertaken by Ireland and Scotland and utilising Gulf 7 samplers successfully mapped and delineated a mackerel spawning boundary within the offshore areas of Hatton Bank/South Iceland Basin and the Scotland-Faroe-Iceland Ridge. The results from these surveys played a useful role in informing the survey planning process ahead of the 2019 MEGS triennial survey. During June 2021 Scotland plans to conclude this exploratory objective by undertaking a further survey up and along the Norwegian Shelf and during the month when the highest mackerel spawning densities are likely to be encountered within this region and the results from the 2019 MEGS survey also confirm this. In addition to the exploratory objective, the proposed survey will also contribute 3 overlapping Gulf 7 transects to the North Sea MEGS survey schedule and the intention will be to also collect adult samples using the pelagic trawl. The survey results will be provided to WGMEGS in time to feed into the planning process of the triennial MEGS survey in 2022.

Mackerel biological sampling data base

Thassya C. dos Santos Schmidt

Institute of Marine Science (IMR, Norway)

Divergences the MEGS adults' database was observed during the WGMEGS meeting in November 2020. Therefore, an effort among the participating countries was made to correct the data and update the time-series. At the moment, the mackerel adults' data have been using in a research collaboration to investigate year class effect of spatiotemporal distribution of mackerel, leading by Anna Ólafsdóttir and Aril Slotte. Aiming only focus on spawning capable fish, a selection of the data was performed and only mackerel older than 3 years at maturing, spawning and spent stages were used. Data were grouped into 4 periods: 1) January to March, 2) April, 3) May, and 4) June and July, and four latitude ranges were established: 1) South of 45°N, 2) between 45° and 50°N; 3) between 50° and 55°N; and 4) North of 55°N. Some preliminary results were presented and we could observed that: i) the age composition in the MEGS database is similar to other mackerel database available; ii) older fish tend to be found earlier in spawning areas compared to younger fish; iii) a shift on age structure composition was observed from 2010 to 2013. The next step is converting the biological database into the ICES database format.

Pilot market sampling for potential fecundity

Ewout Blom¹, Brendan O’Hea² and Cindy van Damme¹

¹Wageningen Marine Research (WMR, The Netherlands)

²Marine Institute (MI, Ireland)

During the last survey very few potential fecundity samples were collected during early sampling periods in the Western area. A pilot was carried out in 2021 to investigate the possibility of increasing the number of potential fecundity samples collected through market sampling. Both Ireland and Scotland agreed to investigate the possibility of the collection of ovary samples from there market sampling first quarter of 2021.

Marine Science Scotland could not collect ovary samples due to the Covid-19 restrictions hampering the market sampling. The Marine Institute in Ireland managed to obtain 30 ovary samples in February 2021 at the correct development stage, Walsh scale 3. This was at the end of the fishing season, when the Irish mackerel quota was almost fulfilled. The vessels were asked to keep mackerel from there last hauls and bring them to shore. The mackerel were sampled within 24-48 hour after catch and ovary samples fixed in formaldehyde.

The screening samples were sent to Wageningen Marine Research for histological analyses of the development stages of the oocytes. 50% of the samples were in right oocyte development stage and could be used for potential fecundity estimation. This collection of ovary samples from the market sampling seems to be a possible solution to collect higher numbers of fecundity samples in the Western area.

North Sea mackerel egg survey planning 2021

Cindy van Damme¹ and Bastian Huwer²

¹Wageningen Marine Research (WMR, The Netherlands)

²DTU Aqua-National Institute of Aquatic Resources (DTU, Denmark)

In 2021 the North Sea mackerel egg survey will be carried out by the Netherlands and Denmark. The survey was originally planned to be carried out in 2020, but had to be postponed due to Covid-19 measures. The survey will be carried out as a DEPM survey, with one coverage of the whole North Sea between 25th May and 12th June. Plankton sampling will be carried out between 53° and 62°N. Each transect a pelagic trawl station is planned to collect ovary samples for batch fecundity and spawning fraction estimation. It is planned to have some stations sampled by both Denmark and The Netherlands for estimation of CV.

Sampling for AEPM and DEPM adult parameters: Atlantic mackerel and horse mackerel.

Maria Korta¹ on behalf of adult MEGS subgroup

AZTI, Spain

From 2013 onwards, sampling has been planned so to achieve enough samples both for the DEPM and AEPM. WGMEGS took the commitment to apply both methods for 5 consecutive triennial surveys. As shown during last WGMEGS meeting, this goal is far from being accomplished, mainly due to the difficulty of balancing the sampling of adults and plankton when survey time is limited. The application of these methods would face serious troubles if ongoing failures in fish collection continue. For instances, the 46% and 42% of the ovaries planned to be collected were obtained in Atlantic mackerel AEPM and DEPM respectively. The percentage decreased to 18% in horse mackerel DEPM. The adult sampling scheme for 2022 survey is similar to that for 2019. However, DEPM sampling scheme required further clarification regarding the collection of hydrated ovaries in both species. And in this sense, the definitions of the adult parameters in both egg production methods as well as the procedure of the joint haul sampling scheme were revised appropriately during the survey planning meeting.

Workshop on Adult Egg Production Methods Parameters estimation in Mackerel and Horse Mackerel 2021

Maria Korta

AZTI, Spain

The next workshop on adult parameters estimation in Atlantic mackerel and horse mackerel was announced and will be held in San Sebastian, 22-26 November 2021. The terms of reference of the workshop cover similar goals to those defined in previous workshops; however, they were updated, limited to 4 and identified according to the ICES Science plan. Before the workshop, a calibration exercise will take place among the participants. Thus, identical images will be sent out to readers and the results will be discussed during workshop. Several tasks were enumerated under each ToR to carry them out during the workshop. Besides, it was considered to move from ICES Survey protocols (SISP) to ICES Cooperative Research Reports (CRR).

The MEGS survey: Sampling strategy

Gersom Costas

Instituto Español de Oceanografía, Spain

This work shows that time, (using week as unit time), has a significant impact in the interpolated value of daily egg production on unsampled rectangles caused by egg production on neighbouring sampled rectangles. This bias in interpolated rectangles could consequently affect the estimate of egg production by Period.

A consequence effect of having sampled significant survey area in a short period of time, (1 week), during a survey Period (duration about 4 weeks), could be the increase of uncertainty in the estimate of total egg production in that Period and therefore in total annual egg production. Since AEPM provides an integrated view of egg production during the spawning season rather than a snapshot as DEPM (Stratoudakis, 2006, Takasuka, 2018),

Horse mackerel egg survey

Gersom Costas¹, Brendan O'Hea²

1 Instituto Español de Oceanografía, Spain;

2 Marine Institute, Ireland

In 2019 peak spawning for horse mackerel was in the first half of July but much lower compared to 2016 and 2013 surveys. In addition, only 3% of the females caught for fecundity estimate in July showed signs of recent spawning. It was argued that this low level of egg production in last few years could be an indication of horse mackerel spawning having shifted later in the year.

Survey maps of observed horse mackerel egg densities during peak spawning (June- July), from 2004 onwards, were analysed. It was noticed that since 2010 alternate transects were sampled during later survey Periods (which coincides with peak spawning), with the aim of covering the whole spawning area. In addition, it was noticed that some stations can have high densities of horse mackerel eggs, but stations on either side may contain low egg densities or no eggs. This could indicate that egg distribution has been patchier in recent years. Since the distribution of eggs is appearing patchier, the distance between sampling stations could be narrowed to ensure more accurate data collection.

This patchier distribution of eggs could also be an effect of a shrinkage in time and space of the horse mackerel spawning season due to the poor status of the western area horse mackerel stock in recent years.

WGMEGS survey questionnaire

Brendan O' Hea

Marine Institute, Ireland

In quarter 4, 2021 MEGS participants were asked to complete a questionnaire providing answers to a number of topics which had been raised in recent years, regarding the surveys. Topics included the timing of the North Sea survey, Institute flexibility regarding the timing of their surveys, ability of Institutes to react to results found during the surveys, availability of ship time to conduct the 2022 surveys, and the switch of the North Sea survey from an AEPM to DEPM methodology. Responses were received from all Institutes. These responses were synopsized and presented at the meeting.

SISP to TIMES

Brendan O' Hea

Marine Institute, Ireland

The ICES SISP series, Series of ICES Survey Protocols, were discontinued at the end of 2020. A new TIMES publication series, Techniques in Marine Environmental Sciences, has been introduced instead. This presentation outlined the procedures, and time lines, involved in applying for a TIMES publication. It also listed changes between SISP and TIMES regarding citation of authors.